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November 2005
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Why a gigantic impact basin holds keys to the solar system's history

GALACTIC HAZARDS

Do we live in a cosmic shooting gallery? p. 34

PLUS:

Astronomers debate the "tenth planet"

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A small asteroid slams into the Moon's farside and explodes, creating the solar system's largest known impact basin. PAGE 50

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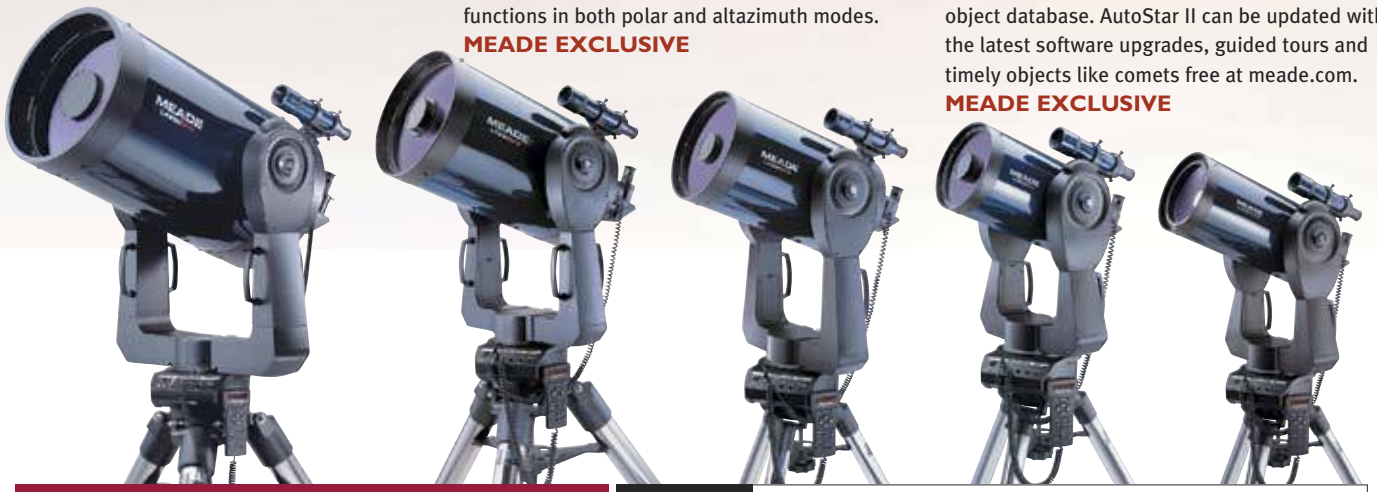

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Explore Hubble's deepest view

RON MILLER FOR *ASTRONOMY*; INSET: USGS

ON THE COVER

Recognized just this past decade, the South Pole-Aitken basin formed when an asteroid slammed into the Moon 4 billion years ago. The immense hole is 1,600 miles wide, 8 miles deep, and, through the splattered mantle material, holds the keys to understanding the solar system's ancient past.

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Observing, telescopes, origin and fate of the cosmos

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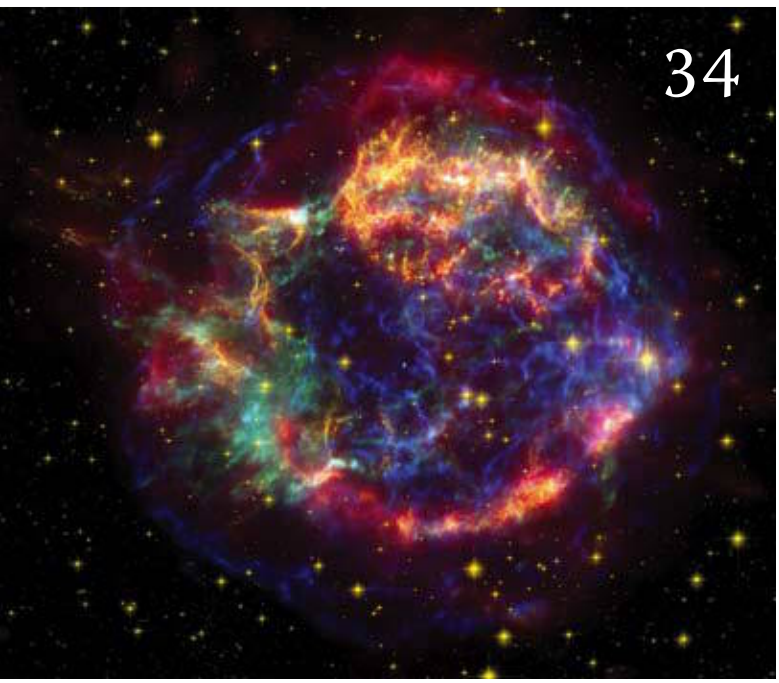

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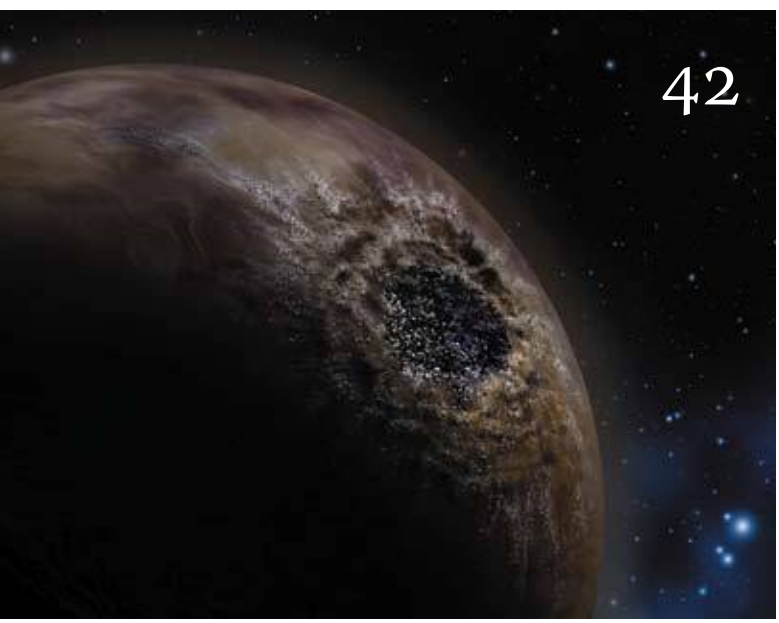

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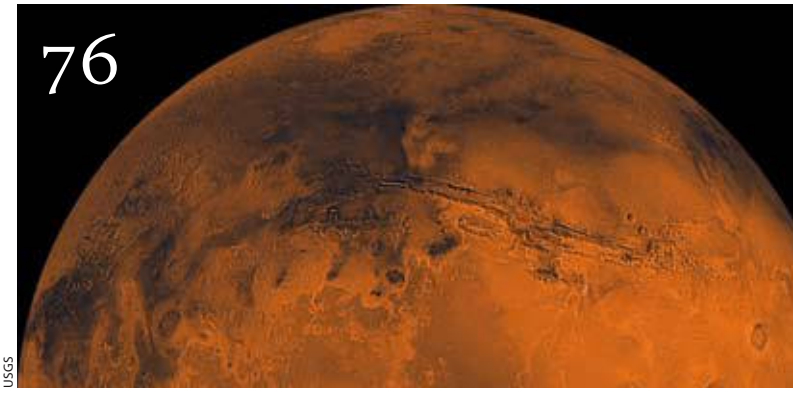

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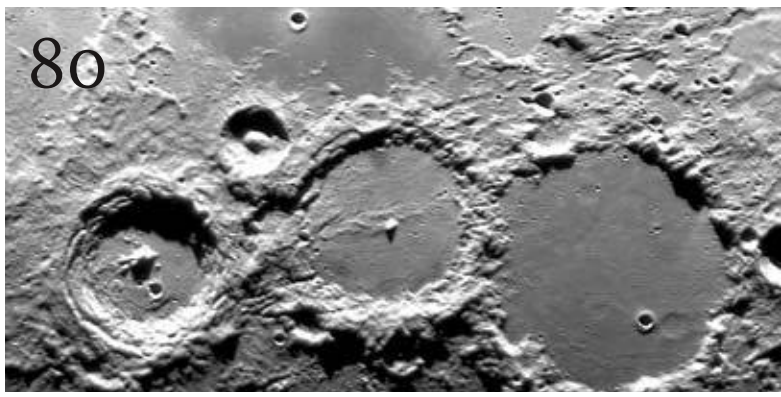

RALF VANDEBERGH

Astronomy
Volume 33, Number 11

Help us choose our cover

Choosing the right cover is a big deal

in the magazine business. The difference in performance on the newsstand between a good cover and a great cover can be, well, astronomical. To bring you the best cover possible, we have begun a process many magazines use: an online cover survey. We place multiple covers online and allow you, our readers, to vote for your favorite.

ONLINE VOTING helped us select the cover for our Special Cosmology Issue in October.

This process, from creating artwork to critiquing our cover blurbs, now starts much earlier in the game. Editors, artists, designers, and marketers are all involved in a more dynamic way.

When we are ready to hold the voting, Editorial Associate Jeremy McGovern is the engine driving the process. He creates the cover survey and informs you about it through our weekly e-newsletter and also posts a notification on our web site, Astronomy.com.

Each month the voting lasts a week, and your response has been amazing. With our most recent survey (as I write this), for the October issue, we tallied more than 1,000 votes, and readers sent us more than 200 written comments, including thoughts about the magazine reaching far deeper than just the cover.

Please keep the responses and votes coming — we love having you involved in this process and hearing your voices.

Beyond the cover

Within the issue you're holding, four big science stories appear. One ties into the celebrated Fermi paradox, a question posed by physicist Enrico Fermi (1901–1954): If the cosmos is populated with intelligent beings, where are they? Shouldn't we have detected them by now? Contributing Editor Steve Nadis suggests in "Do we live in a cosmic shooting gallery?" (page 34) that violent phenomena like supernovae could sterilize planetary systems over time, wiping out much of the life in the universe.

In "The search for diamond worlds" (page 42), Ray Villard of the Space Telescope Science Institute (STScI) describes planets that, once discovered, will make the Hope Diamond look like chump change. These trillion-karat carbonaceous planets may have coal-black surfaces and diamond-like outcroppings.

Another STScI astronomer, Sangeeta Malhotra, describes the latest research on the deepest image ever taken of the cosmos, in "As far as Hubble can see" (page 46).

And space-exploration journalist James Oberg profiles the South Pole-Aitken basin in "The biggest hole in the Moon" (page 50), describing what such a crater may tell us about the early solar system.

Keep those online cover votes coming, and keep enjoying the sky!

Yours truly,

David J. Eicher
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Cloudy Nights Review

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#911X: Threads on to the rear cell of most SCTs, 36mm diameter **$149.95**

Series 4000 Photo-Visual Color Filters

- Increases contrast of fine planetary features

Set #1: #12, #23A, #58, #80A **$49.95**

Set #2: #11, #25A, #47, #82A **$49.95**

Set #3: #8, #21, #38A, #56 **$49.95**

** Individual filters may be purchased separately for* **$14.95**

2" Diagonal Mirrors with UHTC™

- UHTC-coated
- Includes 1.25" eyepiece adapter
- **#929** threads on to the rear cell of most SCTs **$119.95**
- **#930** slides into any 2" focuser **$119.95**

Imaging Accessories

CCD-Photo-Visual Flip-Mirror Systems

#647

#644

- Flip mirrors greatly facilitate precise centering for CCD imaging
- Both #644 and #647 model Flip Mirrors incorporate a flexure-free one-piece body design, locking threaded helical focuser for the eyepiece, precision-polished UHTC-coated mirror diagonal flats, precision X/Y adjustment mechanism for the diagonal mirror with locks for precise centering, and multiple rotating adapters for T-thread and 1.25" O.D. camera attachment
- **#644 Flip Mirror System** accepts 1.25" O.D. eyepiece only and has a clear aperture of 22mm; use with small to medium size chip CCD cameras **$149.95**
- **#647 Flip Mirror System** accepts 1.25" and 2" O.D. eyepieces and has a clear aperture of 40mm; use with medium to large size chip CCD cameras **$249.95**

New Ultra-Wedge (for all LX90™, LX200™, and RCX™ telescope models – one wedge fits all)

- Redesigned for the RCX400™
- Perfect for astrophotography (not for use with 16" model)

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Vibration Isolation Pads for Tripods

- Dramatically reduces vibration-damping time
- Recommended by top astronomers for any telescope

Set of 3 **$49.95**

AC Adapters

- **#541 AC adapter** for ETX-90, ETX-105, ETX-125, LX10 and LX90 **$49.95**
- **#547 AC adapter** for LX200™GPS, LXD55, LXD75™ series telescopes **$69.95**
- **#546 AC adapter** for ETX-70™, DS™-2000, NGC series telescopes **$19.95**

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NEW!
EZ-Pix II Universal Digital Camera Adapter

Taking digital pictures through your scope is as easy as 1..2..3!

EZ-Pix II truly lives up to its name. Simply twist the large knob to secure it onto your eyepiece. Attach your camera by its tripod thread and turn the easy to use micrometric type adjustments until your camera lens is centered over the eyepiece. Once centered tighten the lock knob to secure your adjustments solidly in place. Easily switches from eyepiece to eyepiece or to different cameras. Available in 2 sizes to fit standard 1.25" telescope eyepieces and larger eyepieces commonly found on spotting scopes. Unlike similar units on the market ours is truly universal, including an extension plate to allow you to use cameras with long extending lenses such as the Nikon 5400/5700/8400/8700/8800, Olympus 2000-8000 series, Sony DSC series, Canon A and G series, Minolta DiMage and many, many more.

STEZPIX2S Small, fits eyepieces 28mm to 45mm..... **59.00**
STEZPIX2L Large, fits eyepieces 43mm to 65mm..... **79.00**

ScopeTronix Digital Camera Solutions
We have the worlds largest selection of digital camera adapters

Moving up to a Digital SLR camera?
The MaxView-DSLR is for you!

DSLR II shown on a Canon 10D*

NEW!

Finally a variable projection adapter large enough to hold ANY eyepiece! Now you can use your best eyepieces for astrophotography. The picture at right shows the 1.25" version (left), the 2" version (right) and a standard sized projection adapter between them for scale. The 1.25" version will accept any 1.25" eyepiece. The 2" version will accept any 1.25" or 2" eyepiece...yes even a 31mm Nagler! Both versions include a removable MaxPower lens to increase magnification and allow use in scopes with very little back focus. These are variable length adapters allowing you to adjust the magnification in small increments to fill the frame. Change eyepieces in seconds. Machined from solid aluminum, anodized black with a knurled grip ring. 2" version includes 1.25" adapter. Both units are T threaded for use with standard T-Rings. Can be used with 35mm SLR cameras too! *Camera not included.

1.25" MaxView-DSLR **2.00"**

1.25" *MaxView-DSLR* **(STSLR1) $129.00** | **2" *MaxView-DSLR*** **(STSLR2) $189.00**

MaxView™ & MaxPower™ Lenses
S&T Hot Product 2003!

Our award winning MaxView 40 and new MaxView II Digital Camera Adapters are specially designed eyepieces for use with digital cameras. Designed to give the least vignetting, even when used with large lensed cameras. The MaxView 40 is 1.25" format while the MaxView II is 2" format. We carry dozens of adapter kits to fit either MaxView to most all digital cameras with threaded lenses. Our new MaxPower™ lenses thread into the bottom of the MaxView eyepieces to increase magnification by 60% while maintaining the desirable properties of the MaxView eyepieces. We also have versions made specifically for use with Microscopes and most popular nature scopes such as Swarovski, Pentax, Leica, Zeiss and more! **Patent Pending.**

1.25" MaxView $129.95

*Mounted on Sony 717
2" MaxView II $189.95

Awarded "Hot Product" SKY & Telescope Magazine™ 2003

MaxPower 1™ 1.25" 39.00
MaxPower 2™ 2.0" 69.00

The Digi-T™ System
The world's best selling Digicam Adapter!

Pricing from $59.95 to $119.95

The Digi-T system allows you to use most popular plossl eyepieces with your digital camera. We have dozens of kits to fit all popular digital cameras. *See complete details on our website.*

Fits: Meade 4000 Plossls, Celestron NexStar Plossls, ScopeTronix ST Series, Orion Sirius Plossls, and many more eyepieces with removable rubber eyeguards. *Patent Pending

GPS for your Autostar!

Easy to install unit adds GPS functionality to many scopes. Versions to work with Meade ETX, LX90, LX200 (GPS and Classic), No more entering the time, date, and location! It is all entered for you at very high accuracy! See our website for full details and model number for your particular telescope.

STARGPS $199.00

ScopeTronix 4 in 1 Multi-Mate Alignment Tool

The Multi-Mate has four handy tools for your GOTO scope. It's a compass, a level, a dust cap, and a desiccant chamber. To find "home position" simply place it in the eyepiece port and swing the OTA till the compass indicates North, flip it over and use the bubble level to level the OTA. When storing your scope use it as a dust cap and the built-in desiccant packet will also help prevent mold damage to your optics. Desiccant is easily replaceable by unscrewing the end. Machined aluminum, anodized black.

STMM ScopeTronix 4 in 1 Multi-Mate..... **24.95**
STMMD Replacement desiccant (10 Packets)..... **5.95**

ScopeTronix Thread On Solar Filters for ETX & Tele Vue scopes

Custom machined black aluminum filter cell securely threads onto telescope.

STSF60 fits ETX60 and ETX70..... **64.95**
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STSF105 fits ETX 105..... **94.95**
STSF125 fits ETX 125..... **99.95**
STSF76 fits Tele Vue 76.....***NEW!***..... **79.95**
STSF85 fits Tele Vue 85.....***NEW!***..... **89.95**
STSFB fits Canon 50mm IS(2)..... **99.95**

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STPL06 6mm ST Series Plössl **37.95**
STPL09 9mm ST Series Plössl **37.95**
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STPL15 15mm ST Series Plössl **37.95**
STPL20 20mm ST Series Plössl **37.95**
STPL25 25mm ST Series Plössl **37.95**
STPL32 32mm ST Series Plössl **42.95**
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STPLSET Complete Set (9)..... **249.00**

ScopeTronix Barlow Lenses

STBAR2 2x **39.95**
STBAR3 3x **42.95**
ST2BAR2 2x 2" **79.95**

Color Filter Set
For 1.25" Eyepieces

STCFS...37.95

ScopeTronix Eyepiece Bottles & Filter Cases

ScopeTronix "Bolt-Style" Eyepiece Bottles
STEPB1 Eyepiece Bottle - 1.4" ID, 1.9-2.6" Length **3.00**
STEPB2 Eyepiece Bottle - 1.6" ID, 3.2-4.7" Length **3.00**
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STEPB6 Eyepiece Bottle - 3.1" ID, 4.7-7.0" Length **7.00**

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STBOXL Large (reducer/corrector size box).. **2.95**

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ScopeTronix ETX & NexStar Piggy Back Camera Mounts

STPB70 ETX-60/70..... **42.95**
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Autostar Case

Protect your Auto star from the dew and keep it working like new!

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ScopeTronix Accessory Tray for ETX

Accessory Tray for ETX
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Replacement Eyeguard

Fits many common 1.25" eyepieces.

STEYEG 2.50

ScopeTronix Flexi-Focus™ for ETX Telescopes

Oversized knob and flexible shaft allow crisp, sharp focusing even when OTA is pointed straight up!

STFLEX70 For ETX-60/70..... **34.95**
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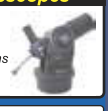
Flexible shaft reduces vibrations Achieve sharp focus fast!



ScopeTronix designs and manufactures many unique products like the patent pending Maxview's, Digi-T, Flexi-Focus, etc... Dealer inquiries are always welcome!

LUMICON The World's Best Filters & Astronomical Accessories

Lumicon International offers the best and most extensive line of astronomical filters in the world. Filters for every imagined visual and astrophotographic application, in many configurations and sizes. Filters for light polluted skies, planets, deep sky objects, galaxies, nebulae, planetary nebulae, comets, and solar prominences. All Deep Sky, UHC, OIII, H-Beta, and Comet Filters are individually tested and proudly inscribed with the percentage of light transmittance of their primary emission lines. Lumicon also offers a complete line of unique accessories, including the World Famous Easy Guider Series, Sky Vector Systems, Diagonals, Finderscopes, and Binocular Viewers. To ensure that Lumicon Products remain the World's Best, the strictest quality control standards are employed throughout the production process. All Lumicon Products are made to the highest standards available and come with a 100% Satisfaction Guarantee - Please Visit www.lumicon.com for Details.

DEEP SKY FILTERS The best light pollution filter on the market today. Blocks all high & low pressure mercury and sodium vapor lamp light, neon lights and airglow, while transmitting the rest of the visible spectrum. Excellent for both visual and photographic applications. Visually, the Deep Sky Filter is most useful under light-polluted skies, from where it reveals faint objects like star clusters, galaxies, nebulae and comets by darkening the background of space. Photographically, the Deep Sky Filter enables deep space photos to be taken through city lights and blocks natural airglow at dark-sky sites, thus improving results in film and CCD astrophotography.

1.25" – $99.95 • 1.25" Questar – $99.95
2" – $199.95 • Cassegrain Rear Cell – $199.95

ULTRA HIGH CONTRAST FILTERS The ULTIMATE nebula filter. The original LUMICON Ultra High Contrast Filter is unbeatable for revealing nebulosity. This achievement in filter performance is attributed to exclusively designed coatings that isolate the two doubly ionized oxygen lines (496 and 501nm) and the H-beta line (486nm) emitted by planetary and most emission nebulae. The result is superb views of the Orion, Lagoon, Swan and other extended nebulae. Useful to great advantage under dark skies.

1.25" – $99.95 • 1.25" Questar – $99.95
2" – $199.95 • Cassegrain Rear Cell – $199.95

OXYGEN III FILTERS The legendary LUMICON OIII narrow bandpass filter isolates just the two doubly ionized oxygen lines (496 and 501nm lines) emitted by diffuse, planetary and extremely faint nebulae. Thus, these faint objects become much more visible against the blackened background of space. The LUMICON Oxygen III Filter produces near-photographic views of the Veil, Ring, Dumbbell and Orion nebula, among many other objects. Performs best under both light-polluted and dark skies. You will be amazed at what the OIII filter allows you to see!

1.25" – $99.95 • 1.25" Questar – $99.95
2" – $199.95 • Cassegrain Rear Cell – $199.95

HYDROGEN-BETA FILTERS The Horsehead Nebula filter. The LUMICON H-Beta Filter isolates only the hydrogen-beta line of the spectrum (486nm) in a narrow pass-band just 9 nm wide. The result is extreme contrast between the black background of space and the delicate Hydrogen - Beta emission of extended nebulae. Now you can view extremely faint, special objects such as the Horsehead, Cocoon and California Nebulae. In many cases, the LUMICON H-Beta Filter is the ONLY way to view these objects. A transparent sky, a 8" or larger telescope, and the LUMICON H-Beta Filter, will tremendously aid in viewing those "notch in the belt" objects.

1.25" – $99.95 • 1.25" Questar – $99.95
2" – $199.95 • Cassegrain Rear Cell – $199.95

COMET FILTERS The LUMICON Comet Filter, a narrow bandpass system (25nm), isolates the 501nm OIII line and both Cyanogen lines at 511nm and 514nm. The high contrast gain of the filter reveals the delicate ionized tail of gaseous comets, allowing you to see their full extent. The Comet Filter also helps you to better distinguish gaseous comets from dusty comets which normally show little contrast gain.

Howard Brewington, famed comet discoverer, says: "I discovered Comet Aarseth-Brewington, 1989a1, using the LUMICON Comet Filter. The filter doubled the contrast, making the comet very easy to spot." Why make comet-hunting harder than it needs to be?

1.25" – $99.95 • 1.25" Questar – $99.95
2" – $199.95 • Cassegrain Rear Cell – $199.95

NIGHT-SKY HYDROGEN-ALPHA FILTERS Not intended for solar observing, the LUMICON Night-Sky H-Alpha Filter is a powerful photographic aid in overcoming light pollution during deep-sky photography. It will greatly reduce light pollution, making it ideal for photography of faint emission nebulae. Exposures may be increased up to 10 times without diminishing the black background in your photograph, thus, achieving strikingly improved results in black & white film and CCD astrophotography. Both filter surfaces have high light transmittance coatings for maximum performance.

NEW 1.25"– $79.95 • 2"– $99.95 • 58mm – $109.95 • 72mm – $119.95 • 77mm – $129.95 • 82mm – $139.95

MINUS VIOLET FILTERS The LUMICON Minus Violet Filter greatly improves photographs taken through lens systems, producing pinpoint star images. It is especially recommended for all telephoto lenses. The Minus Violet filter passes the maximum amount of visible light, including the full blue, green, yellow and red portions of the spectrum. It absorbs violet and ultraviolet light below 420nm, thus eliminating blue halos around bright stars in color photography. In B&W photography it eliminates bloated and swollen star images caused by violet and ultraviolet light, which telephoto lenses cannot focus perfectly, due to chromatic aberration. This filter is unsurpassed in photographic performance.

NEW 1.25"– $59.95 • 2"– $79.95 • 58mm – $89.95 • 72mm – $99.95

LUNAR AND PLANETARY FILTERS LUMICON Lunar and Planetary filters are made from renowned Schott and Hoya optical glass. Each filter is individually precision ground and highly polished with ultra-high light transmittance coatings on both sides for ultimate contrast on lunar and planetary detail. Double stacking filters may also improve lunar imaging. Optimized for both visual and photographic applications. For a complete list of lunar and planetary filters and applications, please visit www.lumicon.com. 1.25" – $19.95 • 2" – $29.95

POLARIZING FILTERS LUMICON Polarizing Filters are manufactured from optically flat Hoya polarized glass. Performs best at cutting all glare and increases contrast on bright celestial objects such as the moon at full illumination, and can be double-stacked with other LUMICON filters for use on bright planets. They are also useful for daylight observation of land, sea and nature. In addition to polarizing the light, they reduce its intensity by a factor of about 3.

Also available in rotating polarized cell designs for variable levels of light transmittance to any value between 5% and 30%.

Single Polarizer 1.25" – $29.95 • 2" – $39.95
Variable Polarizer 1.25" – $39.95 • 2" – $49.95

• NEW • NEW • NEW •

80mm Super Finder System Now Includes Custom Fit Carrying Case!

80MM SUPER FINDER SYSTEM The highest quality finder system on the market today, the newly redesigned LUMICON 80mm Super Finder features exceptionally sharp optics, high contrast views and easy to use functionality. The LUMICON 80mm Super Finder is designed to switch conveniently from straight through to right angle in seconds with supplied extension adapter. Includes a front barrel focuser for fast and precise focusing. In addition, the LUMICON 80mm Super Finder includes a correct image right angle diagonal for hassle free pointing in any direction.

The LUMICON 80mm Super Finder also doubles as a high quality rich field refractor, yielding superb views of the moon, planets, star clusters, bright galaxies as well as daytime images. Use it with the optional Image Visor and reduce glare while increasing contrast and resolution on lunar and terrestrial views.

Objective Lens: Fully Multi-Coated 80mm Achromatic Lens; Focal length: 300mm; Includes a Quality 25mm Kellner Crosshair Eyepiece; Super Finder System Weight: 2.7 lbs. Body color available in Black or White.

80mm Super Finder System – **$299.95**
80mm Super Finder Body (Body Only) – **$219.95**
Image Visor – **$24.95**
2X Fully Coated Barlow Lens – **$39.95**

MULTIPLE FILTER SELECTORS LUMICON Multiple Filter Selectors allow you to switch back and forth between filters without having to thread and unthread them from your eyepieces or diagonal. The nose-piece also has threads, so one filter, such as a neutral density or polarizing filter, can be "stacked" with the others. Leaving one of the slots open lets you compare views with and without your LUMICON filters. Made from solid aircraft aluminum.

1.25" Multiple Filter Selector Features: Fits Standard 1.25" Filters; 5 Filter Positions; 6oz Light Weight Construction; 5/8" Low Profile Design; Includes 1.25" Eyepiece Adapter and T-Thread Adapter. Price – **$129.95**

NEW 2" Multiple Filter Selector Features: Fits Standard 2" Filters; 4 Filter Positions; Light Baffles for Astrophotography; 8oz Light Weight Construction; 5/8" Low Profile Design; Includes 2" Eyepiece Adapter and Male Cassegrain Rear Cell Adapter. *Filters sold separately.*

Introductory Price: **$169.95**

ADVANCED CLEANING KIT The very best cleaning kit ever offered. The LUMICON Advanced Cleaning Kit has everything you need to clean even the most delicate lenses and mirrors. Safe to use on all optical surfaces. Includes LUMICON Lens Cleaning Spray, LUMICON Multi Coated Optics Cleaning Fluid, LUMICON Lens Cleaning Tissue, Ultra Brush Dust Remover, Air Blower Blush, 100% Cotton Swabs, LUMICON Micro-Fiber Cleaning Cloth, "Blow Off" Compressed Air and a Hard Carrying Case.

Introductory Price: **$39.95**

SOLAR PROMINENCE FILTER SYSTEM

The LUMICON Solar Prominence Filter System converts your existing telescope into a Hydrogen – Alpha solar telescope. Viewing the sun in Hydrogen – Alpha light allows for amazing images of solar prominences, solar flares, sun spots, bright filaments and other surface features. Simply use a standard camera T-Ring and SLR camera for full photographic capability. Safely observe and photograph the sun at high and low powers directly through your own telescope.

The LUMICON Solar Prominence Filter System includes three components: 1. The Energy Rejection Prefilter; blocks all harmful radiation before it enters your telescope. 2. The Off-Axis Mask; stops down your objective and holds the Energy Rejection Prefilter. 3. The SPF Body; extremely narrow-band (1.5 Angstrom) Hydrogen-Alpha filter, providing high contrast imaging of solar features. This portion of the filter slides into a 2" focuser or diagonal. Includes a T-Thread camera adapter and a 1.25" eyepiece adapter.

Solar Prominence Filter System for 7" / 8" Cassegrain – $779.95 • Meade 10" SCT – $789.95 • Celestron 11" SCT – $799.95 • Meade 12" SCT – $809.95 • Celestron 14" SCT – $819.95 • Meade 14" SCT – $819.95 • Meade 16" SCT – $899.95

Solar Prominence Filter Kit available for telescopes not listed here. The Off-Axis Mask is not included and can be fabricated by customer. Price - $699.95

For more information, visit www.lumicon.com

DIAGONALS

Enhanced Mirror Diagonals

With 96 - 97 percent light reflectivity, 1/10 wave precision polished optics and individually performed double pass collimation tests, the LUMICON Enhanced Diagonal is a must for a fast and significant upgrade from any standard prism diagonal. Includes standard filter threads for trouble-free changing of eyepieces and accessories while using filters. Made from solid aircraft aluminum.

1.25" Enhanced Diagonal - $99.95
2" Enhanced Diagonal - $189.95

LumiBrite Mirror Diagonals

With greater than 98 percent light reflectivity, 1/10 wave precision polished optics and individually performed double pass collimation tests, the LUMICON Lumi-Brite Diagonal maximizes the performance of your telescope for ultimate contrast and resolution one can get from a star diagonal. The exceptional Dielectric Coating provides for a more durable and longer lasting surface. Additionally, objects appear much brighter, with truer color. Includes standard filter threads for trouble-free changing of eyepieces and accessories while using filters. Made from solid aircraft aluminum.

1.25" LumiBrite Diagonal – $149.95
2" LumiBrite Diagonal – $239.95

Prism Diagonals

1.25" Multi-Coated Prism Diagonal – $49.95
1.25" 90° Correct Image Diagonal – $69.95

BINOVIEWER

The LUMICON BinoViewer allows you to comfortably use both eyes while looking through your telescope. The efficiently designed light beam splitter allows for minimum light loss and improved image contrast up to 40 percent. The LUMICON BinoViewer uses precision polished, Grade-A BK 7 crown glass with the highest contrast and color correction available. Its fully multi-coated optics and roof prism design provides for maximum light transmittance, freedom from ghosting images, and built in image correction. Installs in seconds into standard 1.25" focusers or diagonals. Eyepieces not included.

Specifications: Clear Aperture: 22mm; Focus Travel: 20mm; 1.25" Barrel, Threaded for Filters; Magnification: 1X; Overall Length: 120mm; Weight: 23 oz. Made in Germany.

Price – $799.95

EASY GUIDERS SYSTEMS

The most powerful astrophotographic accessory available today. LUMICON Easy Guiders feature patented radial and rotational off-axis adjustments, combined with a large off-axis pick off prism, selecting bright guide stars becomes a breeze for manual astrophotography or computer controlled auto-guiding.

Newtonian / Refractor Easy Guiders

The LUMICON Newtonian/Refractor Easy Guider allows off-axis guiding directly through the main telescope, preventing differential flexure between your telescope and guide scope, which can ruin your astrophotos. The low profile design installs in seconds into standard 1.25" and 2" focusers. Accommodates standard filters and camera T-Rings.

Newtonian/Refractor Easy Guider 1.25" – $189.95
2" – $189.95

Cassegrain Easy Guiders

The LUMICON Cassegrain Easy Guider allows off-axis guiding with your 5" – 9.25" cassegrain telescope. The included multi-coated 50mm focal reducing lens reduces the f-ratio from f/10 to f/6.5 or f/5, providing a wider field of view, increased edge flatness and shorter exposure times. The faster f-ratio combined with the ease of finding and guiding on bright stars, minimizes guiding error, making for successful astrophotos. Accommodates standard 2" filters and camera T-Rings.

Cassegrain Easy Guider for Celestron 5" – $249.95 • 7" - 9.25" – $249.95

Giant Easy Guiders

The LUMICON Giant Easy Guider is a very powerful photographic and visual tool. Utilizing a large multi-coated 80mm focal reducing lens, the f-ratio of your telescope is reduced from f/10 to f/6.5 or f/5, thus, increasing your field of view and edge flatness as wells as decreasing exposure times. Unlike other focal reducing lenses, the LUMICON Giant Easy Guider has full frame illumination and pin-point star images on 35mm film, 120 format film and large format CCD cameras. Accommodates standard 2" filters and camera T-Rings. Meade 16" LX200 requires separate adapter.

Giant Easy Guider Meade 10" - 16" SCT – $399.95 • Celestron 11" - 14" SCT – $399.95

Easy Guider Accessories

Cassegrain Easy Guider SCT Accessory Adapter – $39.95 • Giant Easy Guider Adapter to Meade 16" LX200 – $169.95 • F/10 Viewing Adapter – $89.95 • SCT Accessory Adapter – $49.95 • Helicoid Focusable Off-Axis Tube – $79.95 • Giant Easy Guider Adapter Ring for Meade or Celestron – $49.95 • Newtonian/Refractor Easy Guider 2" Threaded Focal Reducer – $79.95

CAMERA T-RINGS

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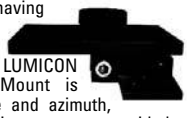

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Will we know life?

I'm surprised at the astrobiologists'

narrow working definition of life that Alan Longstaff refers to in "Quest for a living universe" (April 2005). If something walked up and offered one of our Mars rovers a cigar, would we really wait 1,000 years to see if it could evolve, or reproduce, before we acknowledged that we might have found life?

We have one example, our planet. Life elsewhere, if it really needs liquid, might use molten iron for all we know, and it might find our ethnocentric definition of habitable to be very uninhabitable.

We used carbon because it was in the neighborhood, way back before we decided to call it the only possible option in the entire universe.

Without a water and carbon base, I guess we'd politely turn down the cigar and keep looking for life. **— R. L. GIFFORD,** ADAIR, OKLAHOMA

NASA/JPL

LONELY TRACKS on Mars' Meridiani plains highlight the solitude of the rover Opportunity. It seeks traces of ancient environments once dominated by water — areas that may have harbored life.

A cosmological conundrum

I enjoyed Adam Frank's article "Seeing the dawn of time" (August 2005). Thanks to his clear and concise explanation of inflation, I now have a much better grasp of what had always been a baffling concept.

My new appreciation of inflation has raised a question, though. With the invention of the "multiverse" model, cosmologists created a theory that is permanently beyond any form of empirical verification. As Frank describes the situation, "No signals from one pocket universe could ever reach another."

Doesn't a theory that can never be tested objectively cross the line from physics to metaphysics?

Ironically, Frank intimates that the developers of the multiverse model were motivated by an aversion to the apparent "fine-tuning" of physical laws. He writes, "As you might expect, this apparent fine-tuning of physical laws to allow life has bothered some physicists for many years."

Avoiding "fine-tuning" strikes me as a poor justification for abandoning the scientific method. **— TOM PEARSON,** VIRGINIA BEACH, VIRGINIA

Surprising universe

Bob Berman's "Expect a surprise" (July 2005) gave examples of truly surprising scientific discoveries.

However, I disagree with his inclusion of the "theories" of dark matter and dark energy along with the proven surprises of relativity, neutron stars, and galaxy clustering, to name a few. **— ROBERT POWELL,** AUSTIN, TEXAS

Dark universe

I love Bob Berman's insightful, odd, and often amusing articles, but he threw me a real curve ball with "The masked ball" (August 2005).

He says the night is dark because we cannot see most of the universe — but what about pictures from the Hubble Space Telescope that show a "wall" of galaxies more than 10 billion light-years away? **— JOHN D. VAN DYKE,** SAN MATEO, CALIFORNIA

No walls of galaxies deliver enough light to make our night as bright as day. Night is dark mostly because we do not receive any light at all from the vast majority of all the galaxies that exist, because the universe is too young for the light to have yet arrived. Also contributing to the night's darkness is the dimming of galaxies by the redshifting caused by the universe's expansion.
— BOB BERMAN

We welcome your comments. Send letters to Astronomy *Letters, P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

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BY BOB BERMAN

You go, I'll stay

November is not a great month in the northeastern mountains. Trees turn bare, and birds head south. Just as bad, this month starts the half-year-long cloudy season in much of North America, when the percentage of clear skies drops in half. Stargazing becomes iffy. But astronomers are easily consoled: We know Earth at its worst is still heaven compared to anywhere in space that has no zip code.

I live near Woodstock, New York, home to idealists who would love to establish a happy, lute-playing colony in a bubble on Mars. But the cold truth is space is terribly dangerous. Murphy's Law already has caught on beyond our atmosphere. We reviewed some well-known space tragedies 2 years ago after Columbia was lost ("Trial by fire," July 2003). Now, let's look at some lesser-known events that illustrate just how perilous it is to venture beyond our protective envelope of air.

Start with the very first person who did just that — the first spacewalker, Soviet cosmonaut Aleksei Leonov. On March 18, 1965, when he left his Voskhod 2 capsule and drifted into the void, a weird thing happened. His space suit — a brand-new design — started expanding. The flexible, pressurized material grew larger, like an inflating balloon. When it came time for him to return to the ship, he couldn't fit through the hatch.

Imagine yourself in this predicament. What do you do?

Leonov tried releasing some of the pressure, but the suit already had stretched and wouldn't shrink enough. Finally, when the pressure was down past the safety limit and things were getting desperate — his air was now so tenuous he was in danger of losing consciousness — he managed with great effort to squeeze himself back in. Close call.

People sometimes ask the Apollo astronauts whether they were given suicide pills in case things went badly. Several admitted they had privately discussed the issue. In reality, no pills were taken along, or even needed. A speedy death happens to anyone who simply breaks his helmet.

In space or on the Moon, unprotected skin on a person's shadowed side freezes because it's at least –250° Fahrenheit (–160° Celsius). Simultaneously, brutal ultraviolet-C — never experienced on Earth because our atmosphere blocks it — fries a body's sunlit side. Together with old-fashioned UV-B — 250 times more intense in space than on a summer beach — skin blisters and burns in about 14 seconds.

> You do not report any physical or mental problems unless your head is visibly detaching itself from your body.

Wait, it gets worse. Water boils at ever-decreasing temperatures as one encounters lower air pressure, as in mountain climbing. That's why Denver's coffee is 10° cooler than Boston's. Climbers on high peaks can't make a good cup of tea without a pressure device because water boils when merely warm.

The critical altitude, called Armstrong's Line, is 63,000 feet (19,000 meters). At that elevation, water's boiling point is the body temperature of 98.6° F (37° C). If you go that high or higher, your blood boils automatically.

This is what happened to three unfortunate Soviet cosmonauts in 1971 when a vent popped open while they were still in space. Although they tried desperately to close it, their capsule's air was gone in a minute. Even before the air had left, their blood started boiling into gas.

In space, every liquidy part of the body — such as eyes — will boil and freeze at the same time. This morbidly fascinating demonstration is a physics-lab favorite: Liquids boil wildly but then freeze solid instantly to form a chaotic-looking ice sculpture.

Another little-known peril was encountered by all the Apollo astronauts once they had left the vicinity of Earth's protective magnetic field. They each saw "meteors" whiz in front of their eyes — zips of light, about once a minute. Now, these were military aviators who knew the ropes: You do not report any physical or mental problems unless your head is visibly detaching itself from your body. But crew conversations convinced them everyone was experiencing these bizarre fireworks, so they reported it. Medical experts concluded that cosmic rays had been dashing through their skulls, setting off false signals inside their brains.

Is this really good for you? The long-term health effects are unknown, but they're worrisome. Radiation in space is unavoidable and penetrates space suits and crew with high-energy protons and heavy ions. NASA is trying to learn more: On June 29, 2005, it announced funding for 21 separate space-radiation research proposals.

Apparently, there are two degrees of separation from Earth. It's bold to go beyond our atmosphere. But it's even bolder to venture beyond our magnetosphere.

And quite suddenly, November in northern states doesn't seem that bad. Not so bad at all.

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BY GLENN CHAPLE

Hear ye, hear ye

Mars is back! Raise the banners, strike

up the band, sound the ... Okay, so maybe I'm hyping things up a bit much. Still, it would be hard for me to recreate the media circus that occurred last time Mars was at Earth's back door. I'm referring to the great opposition of late August 2003, when Mars was nearer to Earth — 35 million miles (56 million kilometers) — than at any time in recorded history.

An opposition occurs when a planet farther from the Sun than Earth appears opposite the Sun in our sky — it's the best time to observe a planet.

Most of the time, Mars appears as a minute, featureless disk in all but the largest telescopes. Because of the intricacies of Mars' orbit and the planet's small size, opportunities for a close-up view are relatively rare and short in duration.

Astronomers have to wait more than 2 years from one opposition to the next. Unfortunately, not all oppositions bring Mars as close as we'd like. If it coincides with a time when Mars is near aphelion — the portion of its orbit farthest from the Sun — then it will appear small and obscure. Even during a favorable opposition and when Mars is near the Sun (around perihelion), our observing window lasts a few precious months at best. No wonder astronomers get excited for a favorable Mars opposition!

While the upcoming opposition, slated for the evening of November 6/7, won't break records like the last one, Mars will be an inviting telescopic target. In fact, Mars will be much higher in the evening sky, as viewed from mid-northern latitudes, than it was during the August 2003 opposition.

Before attacking Mars with your telescope, pause for a moment to admire its naked-eye splendor. Shining majestically as a –2.3 magnitude "star" in an otherwise barren tract of night sky, Mars at opposition will be an impressive sight. Although the "Red Planet" is more of a golden yellow or orange hue, it still catches the eye and our imagination. As we gaze at this ruddy beacon, we can understand why early civilizations thought Mars was the god of war — and in more modern times an abode of hostile aliens intent on conquering Earth.

NASA

MARS MANIA will sweep the globe again in November. The Red Planet will stand higher in the sky than it did in 2003.

If you've never seen Mars through a telescope, be prepared for a bit of a letdown. Even though it possesses some of the most spectacular terrain of any solar system body — a volcano (Olympus Mons) that would dwarf Earth's loftiest peaks, and a canyon (Valles Marineris) that could gobble up dozens of our Grand Canyon — its telescopic appearance won't be so awesome.

Mars is a small planet, only about twice our Moon's diameter and many times more distant. During opposition, you'll need 90x just to make Mars appear equal in size to the naked-eye Full Moon. You won't see Olympus Mons or Valles Marineris. Instead, a yellow-orange disk that dances and sways to the whims of Earth's turbulent atmosphere will greet you.

If our atmosphere is more cooperative, you'll be allowed glimpses of grayish areas on the martian disk. You may see a small white spot on its edge. That spot is the southern polar cap.

Take your time at the eyepiece. Observing Mars is a cerebral undertaking that requires patience and quiet contemplation.

During the last opposition, I observed Mars with a 4-inch f/8 reflecting telescope. I was impressed at how much detail such a small scope revealed. Much of my success was due to using color filters.

The filters, threaded to screw into the eyepiece, didn't magically "clean up" atmospheric turbulence. But they did enhance contrast, making elusive detail easier to see.

Two months ago, I suggested an inexpensive alternative to glass filters: the deep-dyed polyester filters sold for theatrical use by GAMProducts, Inc. I purchased a swatch book that contains 1½-inch by 4-inch samples of the various GamColor filters. I discovered that GamColor's GC290 (fire orange) filter is a nice alternative for the #23A, while GC888 (blue belle) performs like the #80A.

I cut out a 1-inch square of each color, and mounted them in side-by-side ½-inch square windows cut from a 3- by 5-inch piece of cardboard. With Mars centered in the eyepiece, I placed the cardboard between the eyepiece and my eye, alternating between red and blue. If you want to make your own filters and experiment with other colors, visit www.gamonline.com.

I'm off to get my ladder out of the garage so I can do some rooftop shouting. Hear ye, hear ye, Mars is back!

Next month: More Mars musings, and we'll get ready for December fireworks. Clear skies.

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Offer Good Through: December 3, 2005

BY PHIL HARRINGTON

You connect the dots

After the Big Dipper and Orion, the most recognizable pattern of stars visible from the Northern Hemisphere may be the "W" of Cassiopeia, the mythical Queen of Ethiopia. As a circumpolar constellation for many northerners, Cassiopeia's five stars are visible on clear nights.

This time of year, Cassiopeia rides high above Polaris and looks resplendent in the Milky Way's gentle glow. Let's set our binoculars on this dazzling target.

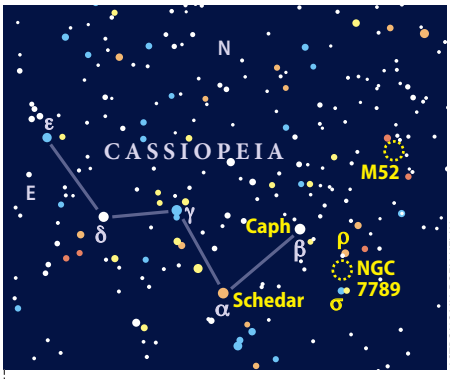
W marks the spot

One of my favorite open clusters in Cassiopeia is **M52**. To find it, draw a line from **Schedar** to **Caph**, the westernmost stars in the W pattern, and continue it an equal distance to the northwest. There, you should spot a slender, four-star diamond pattern. M52 lies to the diamond's south.

Although about 200 stars call M52 home, few are bright enough to crack the binocular barrier; the rest blend into a little cloud of misty starlight. Whenever I look at M52 through binoculars, I recall what Charles Messier saw when he discovered the group September 7, 1774. He described it as "a cluster of very small stars mingled with nebulosity."

Sit back and scan the area around M52 for interesting knots and small clumps of stars. Try to look for patterns and create your own mini-constellations. That's exactly what John Davis was doing when he bumped into a little pattern that's just to the northwest of M52.

You've met Davis a few times in Glenn Chaple's "Observing basics" column. He's what I describe as an old-fashioned amateur astronomer. Rather than relying on newfangled gadgets and gizmos, Davis prefers to star-hop across the sky. Davis has observed thousands of established deep-sky objects in his 6 decades as an amateur astronomer. During this time, his sharp eyes and creative mind have assembled several asterisms. An asterism is a pattern of stars that, although not a full-fledged constellation, can be readily recognized.



ASTRONOMY: ROEN KELLY

CONNECT THE DOTS. After you've found M52, scan the area and see what shapes you can form. Can you see Davis' airplane?

One such pattern is in the same binocular field as M52. See anything? Before reading on, go outside and find M52 through your binoculars. Then, with M52 centered in the view, shift your attention just to its northwest. You'll see a lot of stars, but do any seem to form a recognizable pattern?

To Davis, they do. He sees an airplane. The four stars in our narrow diamond frame its wings. As Davis explains, "The plane's brightest star [labeled as 4 Cassiopeiae on star atlases] marks the end of the eastern wing, while a lone 6th-magnitude star lies at the tip of the western wing. A short arc of faint stars stretching northward forms the plane's crooked tail." Now, when I look at it, I say, "Of course, there it is." Good eyes, John!

Shape your universe

As long as we're hunting for asterisms, look a little to the northwest of the "Davis airplane," into Cepheus. Can you find a half circle formed by a dozen 8th-magnitude stars? The arc measures about 1.5° across, and, to me, it looks like a sideways bowl or maybe a satellite television dish antenna.

Once you've enjoyed M52, the Davis airplane, and the Dish, return to the star Caph in the Cassiopeia W and have a look around. Can you spot three pairs of stars just to its south-southwest? Although none of these is a true binary star system, each pair forms the corner of a slim triangular asterism that reminds me of a skinny hang glider. The brightest star in the asterism, **Rho (ρ) Cassiopeiae**, is one of the two at the nose of the hang glider, while 5th-magnitude **Sigma (σ) Cassiopeiae** — the brighter of the two stars — is at the end of the southern wing.

You might even spot a faint stain on the leading edge of the glider's southern wing. That's actually **NGC 7789**, a distant open cluster discovered in the fall of 1783 by Caroline Herschel, William's sister. Don't expect to see a lot of stars through your binoculars, however. Instead, NGC 7789 looks like a faint, round glow with perhaps one or two elusive points shining through.

There are many more star clusters visible through binoculars within Cassiopeia. I discuss some others on Astronomy.com this month, so be sure to stop by. Next month, we'll shift our attention from mother to daughter as we go hunting for deep-sky targets in Andromeda. Till then, remember: Two eyes are better than one.

ONLINE EXTRA In addition to M52 and NGC 7789, Cassiopeia hosts other binocular-friendly targets. To add other open clusters to your search, visit www.astronomy.com/toc

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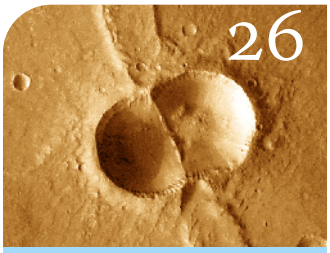
EUROPA PREVIEW? In March, scientists discovered a 3-square-mile community of clams and microbes living off gases — probably methane — spewing from small mud volcanoes under Antarctica's Larsen B ice shelf.

news 11

Glacier spied on Mars, Japanese probe explores asteroid, "old" galaxy has new arms, why the sky is blue, NASA's exotic destinations, probing neutron stars

ESO

GIGANTIC SURPRISE. Spiral galaxy NGC 300 is twice as large as previously thought, leading astronomers to reconsider the Milky Way's size.



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28 Mapping the sky: Sloan Digital Sky Survey II

32 Saturn's small-but-active moon, Enceladus

A super-size galaxy raises big questions

Spiral galaxy NGC 300 in Sculptor is larger than previously believed — possibly by a factor of 2 or greater. A team of Australian and American scientists made the discovery using the Multi-Object Spectrograph on the Gemini South Telescope in Chile. In light of this, astronomers will have to reconsider the sizes of other spirals.

Current theories suggested observations would reveal the galaxy's star count falling off sharply at some radius. Instead, the team found faint stars up to 47,000 light-years from the galactic center and no fall-off. This doubles the disk's previously known radius.

Prior observations incorrectly measured the star numbers in NGC 300 because of the extended stellar population's faintness. "Previous studies lacked the sensitivity to accomplish this," explains team member Bruce Draine.

This finding has implications closer to home. "Our galaxy is much more massive and brighter than NGC 300, so on this basis, our galaxy is also probably much larger than we previously thought — perhaps as much as 200,000 light-years across," says Joss Bland-Hawthorn, chief author of the paper in *The Astrophysical Journal* (August 10, 2005).

Beyond the Milky Way, astronomers also need to answer how spiral galaxies can form with stars located so far from their core. To solve this quandary, "deeper" observations must be made with powerful instruments. **— JEREMY McGOVERN**

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ONWARD. NASA's Deep Impact probe has been redirected to fly past Earth in late December 2007. The maneuver gives mission controllers the opportunity to send the spacecraft past other targets in the future.

ESA/DLR/FU BERLIN (G. NEUKUM)

Mars Express spots ice sheet in crater

GLACIER. A sheet of water ice about 7.5 miles (12 kilometers) wide sits within an unnamed crater on Mars' northern lowlands in an image taken with Mars Express' High Resolution Stereo Camera. The ice sheet stands about 700 feet (200 meters) above the crater floor.

Scientists think the sheet formed on top of a field of dark sand dunes, part of which appears at about 8 o'clock on the ice-sheet's near side. Frost covers parts of the crater walls. — ROBERT BURNHAM

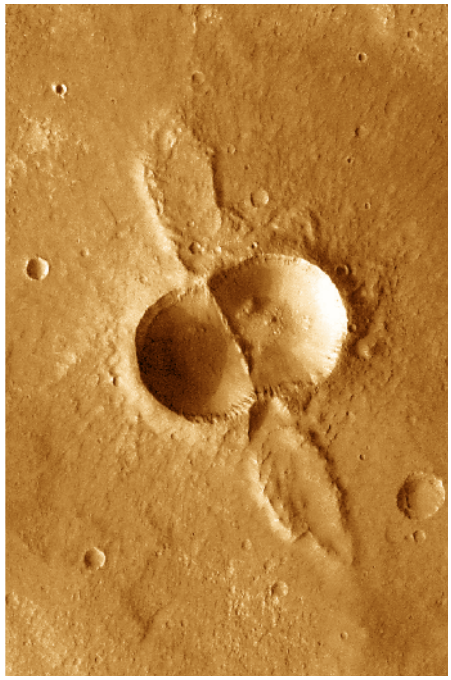
The life and times of Sirius B

The white dwarf orbiting Sirius began its life as a blue star with 5 times the Sun's mass, say astronomers in Arizona and New Mexico. If this blue star still shone today, Sirius would be so bright it would cast shadows on Earth.

Just 8.6 light-years away, Sirius is already the brightest nighttime star. It is a double star with an A-type main sequence star and a faint white dwarf — the closest white dwarf to Earth.

Sirius B was once a main sequence star. Then it swelled into a red giant and shrank into a white dwarf. The astronomers estimate the star shone as a main sequence star and then a red giant for 101 to 126 million years — the expected lifetime of a star born with about 5 solar masses.

The astronomers will publish their work in *Astrophysical Journal Letters*.
— KEN CROSWELL



NASA/JPL/ASU IMAGE 20050715A

BANG, BANG

TWO FOR ONE. A small asteroid broke in two shortly before hitting Mars and left a pair of craters, each 2 miles (3.2 km) wide. Intersecting shock waves raised the straight ridge between them and squirted rocky debris sideways to make the two ejecta lobes. This THEMIS image from Mars Odyssey spans about 7 miles (11 km). — R. B.

Mars cold & dry for billions of years

Studies of eight meteorites from Mars show the planet has been cold and dry for most of the last 4 billion years, say two researchers. Writing in *Science* (July 22, 2005), David Schuster of Caltech and Benjamin Weiss of MIT find Mars has been too cold for liquid water to be plentiful for most of its history.

The team examined published data on the relative amounts of radioactive isotopes in known Mars meteorites. One of these isotopes, potassium-40, decays into the gas argon-40 and leaks out of the rock at a rate dependent on temperature.

The amount of argon-40 left in the meteorites shows the meteorites have not been warmer than 32° Fahrenheit (0° Celsius) since they formed billions of years ago. **— R. B.**

NASA/JSC

SLOW LEAK. Escaping argon gas shows martian meteorite ALH84001 has spent less than a million years above freezing during the past 3.5 billion years.

Falcon approaches Itokawa

After a 2-year ion-engine-powered chase, Japanese space probe Hayabusa (Falcon) has gradually been approaching the asteroid (25143) Itokawa during the past several months.

Original plans to match orbits by June were delayed because of a loss of some electrical power from the craft's solar cells. This resulted in less thrust from the ion drive. Now, the probe is slated to reach the asteroid in early September.

JAXA

RAPTOR SPACECRAFT. Japan's Hayabusa mission will rendezvous with the asteroid Itokawa, collect samples, and return them to Earth in 2007.

The potato-shape Itokawa is roughly 1,600 feet (490m) long. Its gravity is so weak — only about 1/100,000 of Earth's — that Hayabusa won't bother to orbit the asteroid.

Instead, it will hover about 12 miles (20 km) away, surveying the surface both from the fully sunlit side and then from above the terminator, the day/night line.

After several weeks of surveying, Hayabusa's main task will begin: retrieving about a gram of dirt from up to three points on the surface, and then returning them to Earth 2 years later.

To perform this delicate operation so far away from Earth — too far for mission control to operate the spacecraft "live" — the probe carries a sophisticated autopilot.

Using small liquid-fueled engines (and not the low-thrust ion drive that powers the craft during interplanetary cruising), Hayabusa will carefully approach a chosen touchdown point.

The probe will use a laser to measure its range and speed and, half an hour before contact, it will deploy an optical sensor into the soil so its camera can sense any horizontal drifting.

The first sensor, which is about the size of a softball, carries almost a million names of people who supported the project.

The probe will touch the surface with a large, conical sampler "horn," and almost immediately fire a bullet into the dirt.

Some of the material that scatters from the impact will make its way into a collection chamber, where it will be sealed away hermetically for the return trip.

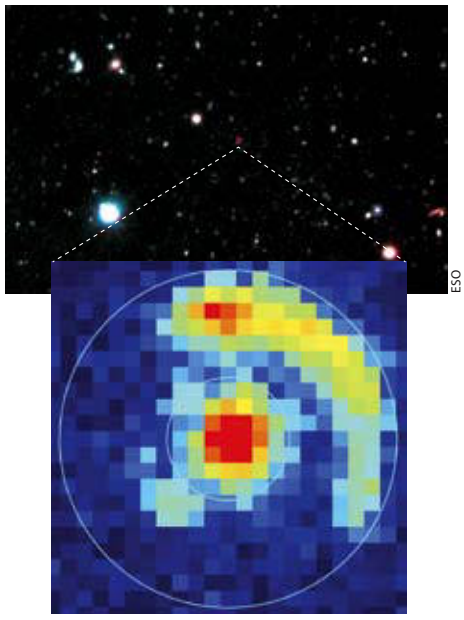
The spacecraft can repeat this process, collecting samples, at up to three different locations.

Hayabusa will also deploy a small "hopper" robot named Minerva. This solar-powered mini-spacecraft will relay images from its three cameras to Hayabusa whenever the two vehicles are in direct line-of-sight contact.

Assuming Hayabusa's power system and ion engines continue to function, the craft will return to Earth in July 2007.

A special capsule will hit our planet's atmosphere at 28,800 mph (46,000 km/hr) — about the same speed as an Apollo spacecraft returning from the Moon — and undergo forces of about 25 Gs before touching down in Australia.

The asteroid samples will be brought to a new national laboratory in Japan. There, they will be analyzed, and some of the sample will be shared with foreign investigators. — **JAMES OBERG**



ESO

COSMIC BULL'S-EYE. ESO astronomers have found the farthest Einstein ring (inset). In this enlarged view, the lensing galaxy is the central red dot, and the lensed galaxy is the colored arc around it. Circles show distance in 1" increments.

Far-out Einstein ring

Using the European Southern Observatory's Very Large Telescope, Remi Cabanac of Pontifical Catholic University in Santiago, Chile, and his European colleagues have found the most distant Einstein ring known.

An Einstein ring is a kind of cosmic mirage in which gravity from a foreground galaxy distorts light from a background galaxy into an arc. The more precise the line-up, the more the far galaxy warps into a ring. The new object, dubbed FOR J0332-3557, arcs through 75 percent of a circle. The lensing galaxy seems to be an isolated, inactive, trillion-solar-mass elliptical perhaps 40,000 light-years across. The more distant object is a compact galaxy less than 1/6 this size brimming with bright clusters from a recent burst of star formation.

The lensing galaxy is about 8 billion light-years away and magnifies the background galaxy, which is 12 billion light-years away. Thanks to the objects' close alignment, astronomers glimpse a galaxy as it was when the universe was only 12 percent of its present age. — **FRANCIS REDDY**

GOING AND GOING. Supernova 1979C in galaxy M100 is as X-ray bright today as it was 16 years ago. The shock wave is slogging through a thick shell of dust the star shed before its death, creating the high-energy emission.

Mapping the sky

The most ambitious astronomical sky survey undertaken has secured funding to continue collecting data. The Sloan Digital Sky Survey (SDSS) was originally scheduled to end this year, but it has been extended through summer 2008.

The SDSS has already measured the brightness, color, and position of hundreds of millions of stars, quasars, and galaxies since its first light in June 1998. The 3-year extension, called SDSS-II, has three components that will add to its already impressive list of discoveries during the last 7 years — most notably the universe's cosmic-web structure.

The first part, LEGACY, will extend the current survey of the extragalactic universe. It will take images of and measure distances to a million galaxies and quasars in a portion of the sky in the Northern Hemisphere, similar to what SDSS does.

The second part of SDSS-II is the Sloan Extension for Galactic Understanding and Exploration (SEGUE). SEGUE will map the Milky Way's structure and stellar makeup. Astronomers can then study the "ages, chemical compositions, and distribution of stars [which] are major clues to understanding how our own galaxy formed, and, by example, how galaxies, in general, formed," says Heidi Newberg, an SDSS member from Rensselaer Polytechnic Institute in Troy, New York.

For its third project, SDSS-II will measure the distances to supernovae, so astronomers can map the universe's expansion rate to verify dark energy's existence.

SDSS is a database, with data available for both the public and the science community. The SDSS telescope is a 2.5-meter reflector located at Apache Point Observatory in Sunspot, New Mexico. Twenty-three institutions make up the SDSS consortium. **— LIZ KRUESI**

ARC AND THE SDSS COLLABORATION

SEEING STARS — AND GALAXIES. The open star cluster NGC 2420 shows an incredible amount of detail when imaged with the SDSS 2.5-meter telescope.

"Old" galaxy has new arms

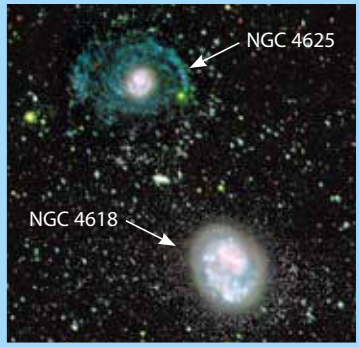
NASA's Galaxy Evolution Explorer (GALEX), an ultraviolet satellite observatory, has photographed spiral arms surrounding a galaxy 31 million light-years away that astronomers thought was old and armless. The galaxy, NGC 4625, may resemble what a young Milky Way looked like.

"This galaxy is an amazing surprise," says Armando Gil de Paz of Carnegie Observatories in Washington, D. C., who led the team reporting in *Astrophysical Journal Letters* (July 1, 2005). "The stars in the arms are about a billion years old," he says, "while the stars in the body are about 10 times older."

Team member Barry Madore, also of Carnegie Observatories, comments, "We don't understand how stars were created in our own galaxy. This nearby galaxy represents one of our possible histories."

Images of NGC 4625 taken in visible light in years past showed only the oval central nucleus with just faint hints of spiral arms. GALEX's ultraviolet images, however, show several arms crowded with hot, young stars that shine primarily in the ultraviolet.

GALEX also imaged nearby companion galaxy NGC 4618, but it has no arms, and astronomers are puzzled. "Interactions between galaxies can spur the creation of stars," says Caltech's Chris Martin, principal investigator for GALEX. "But we don't know why only one galaxy ended up with arms." **— R. B.**



NASA/JPL-CALTECH/CARNEGIE OBSERVATORIES

OUT OF HIDING. Newly discovered spiral arms around the galaxy NGC 4625 show it is 4 times larger than previously thought. The role (if any) played by nearby NGC 4618 remains a mystery.

Botox for asteroids

The impact that made Shoemaker Crater on asteroid Eros shook the body hard enough to erase smaller craters over 40 percent of the surface, say Peter Thomas of Cornell University and Mark Robinson of Northwestern University.

Their finding suggests that under a surface layer of rubble perhaps 700 feet (200m) thick, Eros is solidly monolithic. It also hints scientists can estimate how solid an asteroid is (or how thickly it is covered in rubble) by how cratered it appears.

As they report in *Nature* (July 21, 2005), Thomas and Robinson mapped the asteroid, noting areas where small craters are absent or degraded.

They first considered debris from bigger craters covered the small ones, but determined this would have required too much debris. Moreover, the location of large debris thrown from the big craters didn't fit the asteroid's observed smoothening pattern.

CORNELL/NORTHWESTERN, P. THOMAS, M. ROBINSON

BIG RUB-OUT. Big impacts, most recently 4.7-mile-wide (7.6 km) Shoemaker Crater, have erased small craters over much of 21-mile-long (33 km) Eros.

They propose seismic shaking smoothed Eros' surface. Two smaller smooth patches also adjoin Psyche Crater, which is somewhat older than Shoemaker. **— R. B.**

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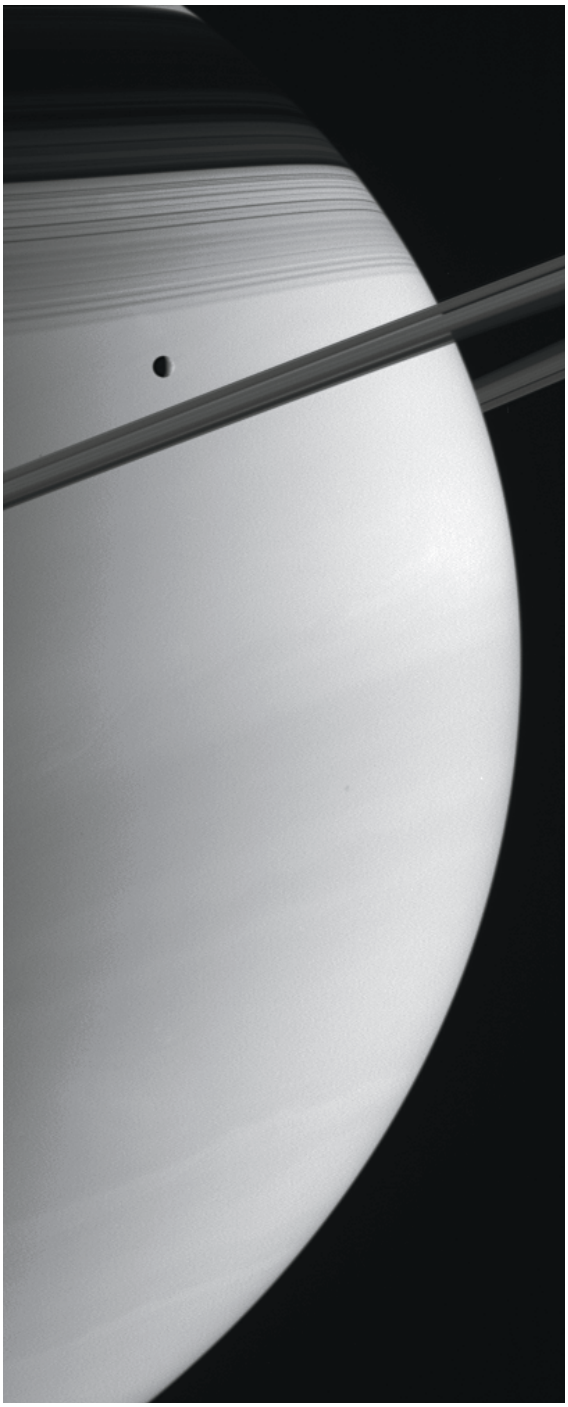
OBSERVATORY ARMED WITH LASER. In 2006, a newly developed laser will be installed on the Subaru Telescope on Mauna Kea, Hawaii. The laser will produce an "artificial star" anywhere in the sky that will act as a focusing target.



NASA/JPL/SSI

A moon among shadows

SMALL TREASURE. Saturn's moon Tethys — which measures 665 miles (1,000 km) across — orbits Saturn at a distance of 180,000 miles (300,000 km) every 2 days. Italian astronomer Giovanni Domenico Cassini discovered Tethys in 1684. The Cassini spacecraft's wide-angle camera snapped this image June 10, 2005, at a distance from Saturn of 900,000 miles (1.4 million km). — R. B.

Nothin' but blue skies

Why is the sky blue? Georgia Tech's Glenn Smith shows in the July issue of *American Journal of Physics* that our perception of sky color depends as much on physiology as it does on physics.

Sunlight passing through Earth's atmosphere ricochets off oxygen and nitrogen molecules. Light with the shortest wavelengths scatters best, which is why we see lots of blue. Yet other colors are there, too. In fact, there's as much violet light as blue.

If the right combination of wavelengths strikes our eyes' color-sensitive cone cells, Smith says, we perceive the mixture either as a single pure hue or as a pure color blended with white light. For example, we perceive the right mix of pure red and pure green light as yellow.

The sky's spectral palette similarly tricks the eye, stimulating it just as a specific blend of pure blue and white. The result: light blue. **— F. R.**

MICHAEL CARROLL

FLOATING ABOVE TITAN. A blimp might survey the surface of Saturn's moon Titan.

Exotic destinations

A committee of scientists, engineers, and policy-makers met in Boulder, Colorado, in June to pound out ideas for future space missions. NASA asked the assembly, called the Outer Planets Advisory Group (OPAG), to suggest strategies for exploring the outer solar system, including asteroids, comets, and the Kuiper Belt.

Fran Bagenal, committee chair, says, "The high point of the meeting was a recognition that Europa is the top-priority target and that we have support from [NASA] to make it happen."

Other candidates include a return to Saturn's sludgy moon Titan — perhaps even doing an aerial survey. OPAG also selected a mission to Neptune to explore its big moon Triton, and visits to Kuiper Belt objects. **— MICHAEL CARROLL**

Right place, right time

Even though they didn't realize it at the time, a group of high-school teachers recently took some of the earliest images of a new supernova in the Whirlpool Galaxy (M51).

Eighteen teachers participating in a science education workshop conducted by the National Optical Astronomy Observatory (NOAO) were learning how to take images in different colors with Kitt Peak's WIYN 0.9-meter telescope June 30. They learned later they had seen a new supernova.

German amateur astronomer Wolfgang Kloehr discovered the supernova, SN 2005cs, June 28. The object was confirmed by Lick Observatory June 30. **— L. K.**

WIYN/NOAO/AURA/NSF

SUCCESSFUL LESSON. The new supernova in M51, circled, was observed with the WIYN 0.9m scope.

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RECEIVES THE CANON EOS 20Da DIGITAL SLR

This picture of the ecliptic was taken January 27, 1995 – it shows a single-frame composite of the 4 brightest objects in the sky (the Sun (yellow), Venus, the Moon, and Jupiter, l-r) rising from nearly the same point on the horizon. The photo was started at about 3A.M. with Jupiter rising first. A 1-second exposure at F/2.8 on ISO 100 slide film was taken with a 35mm camera and 50mm lens every 6 minutes (manually). The Fire Island Lighthouse (NY) is in the foreground.

Astronomy magazine

Canon

Saturn's small-but-active moon

On July 14, NASA's Cassini spacecraft made its closest flyby yet of a saturnian moon. Swooping within 110 miles (175 km) of Enceladus' surface, Cassini found a vast cloud of water vapor above the south pole and surprisingly warm fractures from where the gas likely escapes.

The ion and neutral mass spectrometer found water vapor makes up about 65 percent of the moon's atmosphere. Molecular hydrogen adds another 20 percent, and the rest comes mainly from carbon dioxide, carbon monoxide, and molecular nitrogen. The water vapor's density changes with altitude, suggesting it comes from a local source akin to a geothermal hot spot.

For an atmosphere to persist on such a small, low-gravity world — Enceladus measures just 310 miles (500 km) across — indicates some process continuously replenishes the water vapor.

Scientists think the culprit is evaporating surface ice warmed from below. The heat probably comes from tidal energy, the same source that powers volcanoes on Jupiter's moon Io and softens the icy surfaces on two of Io's jovian siblings, Europa and Ganymede.

NASA/JPL/SSI

CALL OF THE WILD. "Tiger stripes" near the south pole dominate this false-color view of Saturn's mysterious moon Enceladus.

High-resolution images of Enceladus' south polar region show a younger and more fractured surface than elsewhere on the moon. Icy boulders the size of houses litter the landscape, but there is little of the fine-grained frost that covers the rest of the moon. Images also reveal several long, bluish cracks, or faults, scientists were quick to dub "tiger stripes." Mission planners hope to discover more as Cassini continues exploring. — **RICHARD TALCOTT**

Probing neutron stars

Astrophysicists believe the most intense cosmic blast ever recorded (detected December 27, 2004) may hold clues to the inner workings of neutron stars.

The burst originated from a magnetar, a highly magnetized neutron star. As the magnetar's magnetic field shifted and reconnected inside the star, radiation was released. This radiation hit Earth with gamma rays, followed by a tail of X rays.

Astrophysicists had detected a strong X-ray signal every 7.56 seconds shortly after the burst, corresponding to the magnetar's 7.56-second rotation. After studying data from NASA's Rossi X-ray Timing Explorer, astrophysicists have found oscillations within the known X-ray signal. The astrophysicists detected oscillations between 170 to 220 seconds after the burst and oscillating at a frequency of 92.5 Hz. The scientists' work appears in *Astrophysical Journal Letters* (July 20, 2005). — **L. K.**

NASA

INTENSE BURST. It's a good thing SGR 1806-20 is 50,000 light-years away.

Target: infinity

Canon's announcement of its new EOS 20Da digital single-lens reflex camera was welcome news to amateur astronomers. Experienced astroimagers dissatisfied with their current camera, and photographers just getting started in celestial imaging, will find the 20Da a good choice. In addition to all the features of Canon's highly rated 8.2-megapixel EOS 20D, the 20Da ("a" for astroimaging) offers three advantages to astroimagers.

1) Diffuse, reddish nebulae are popular targets among astroimagers. These objects glow red because they emit a specific wavelength of light called Hydrogen-alpha (Hα) radiation. Most digital cameras feature a filter on the image sensor designed to block infrared light. Unfortunately, this filter also blocks Hα radiation, so it prevents reddish nebulae from being captured. The infrared filter in the 20Da is 2.5 times more sensitive than the 20D to visible Hα light, so it lets users capture beautiful images of these objects.

2) Astroimagers attempting long exposures with conventional digital cameras encounter grain-like "noise" throughout the image. Noise worsens as ambient temperature rises and as exposures get longer. The 20Da's image sensor, plus a second-generation on-chip noise-reduction circuit, minimizes this problem. For extremely long exposures, the 20Da features a "Reduce noise for long exposure" mode in the custom function menu that nearly eliminates all noise, even at high ISO settings.

3) Astroimagers often struggle to achieve a sharp focus. Celestial objects are too faint for digital-camera autofocusing, so the camera must be focused manually, a sometimes painstaking process. To make focusing easier, the 20Da offers "Live View" mode, which lets users focus in real time while watching the rear-mounted LCD monitor. Live View also displays the object's central region magnified either 5 or 10 times.

Canon

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*** Includes standard accessories (strap, battery, software & cables).**

Do we live in a cosmic shooting

Eerie connections between high-energy bursts and extinctions on Earth may explain more than our own history. /// BY STEVE NADIS

At Los Alamos National Laboratory in the summer of 1950, Enrico Fermi, Edward Teller, Herbert York, and Emil Konopinski talked — as physicists are wont to do — about flying saucers and aliens. In the middle of lunch, out of nowhere, Fermi suddenly asked, "Where is everybody?"

Fermi's colleagues knew just what he was talking about, and his question has evolved into what's known as "Fermi's paradox." Intelligent beings could have spread across the Milky Way on short time scales compared to the galaxy's lifetime, yet there's no sign of them. So, where are they?

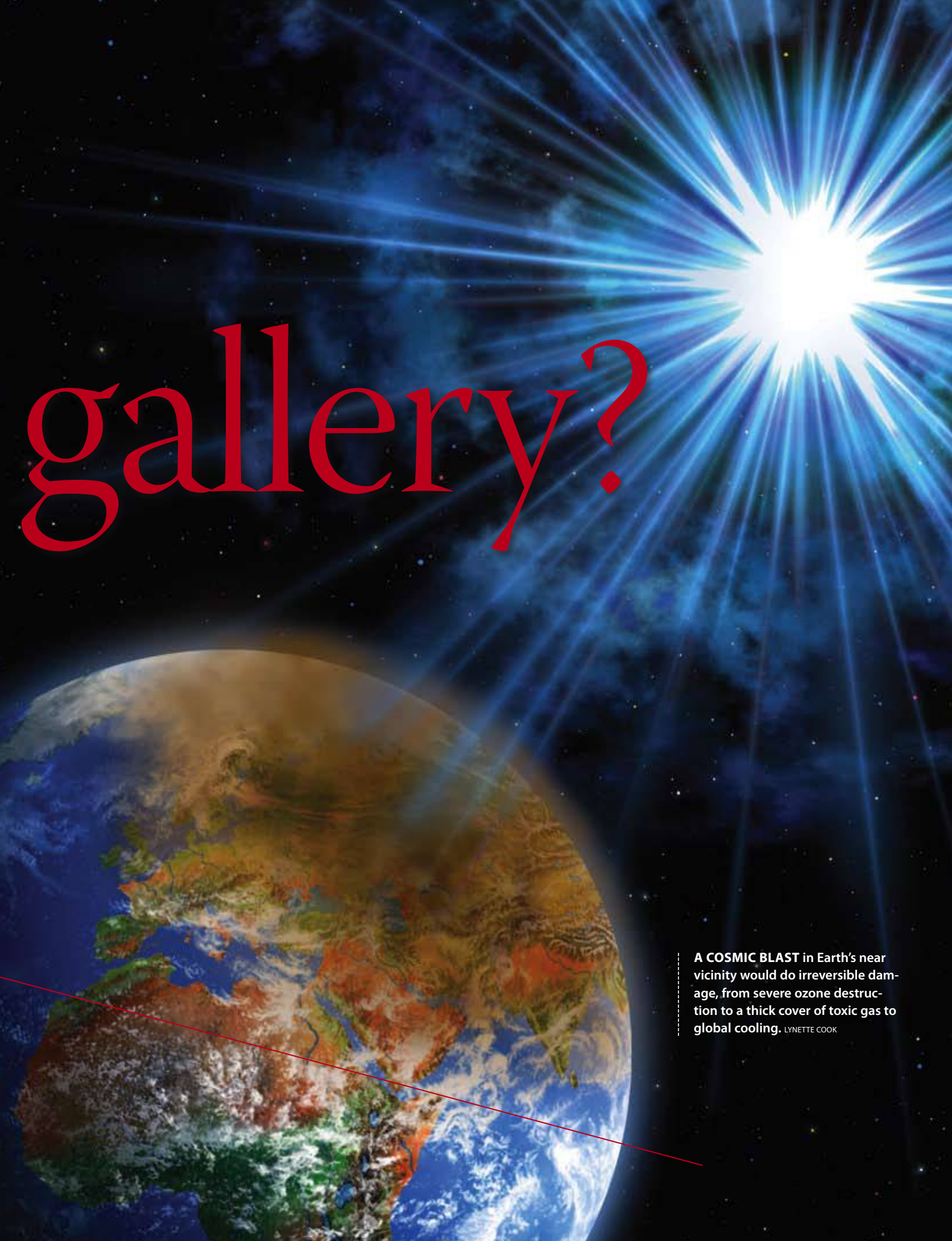
An armory of possibilities

People have debated this question ever since the now-famous lunchtime chat. One possibility is that we are alone. But many scientists find that argument unsatisfying: Why, in a galaxy of hundreds of billions of stars, where planetary systems seem to be commonplace, should intelligent life appear just once? In 1983, science-fiction writer (and physicist) David Brin conjured up more exotic reasons for the "great silence." Our alien superiors may be keeping the solar system as a zoo or nursery to "nurture new sentience." Or perhaps they avoid grimy, unappealing destinations like Earth.

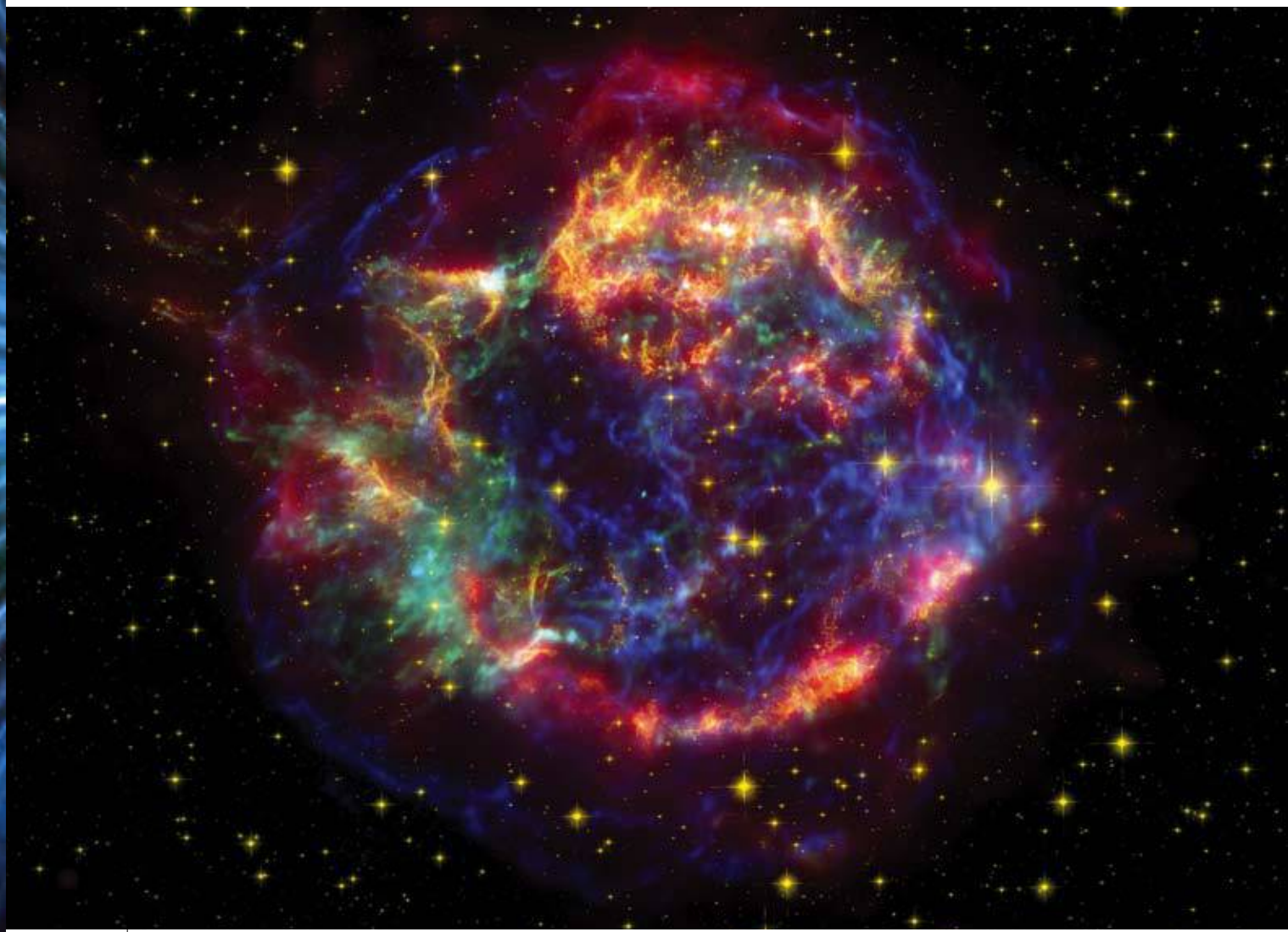
Yet another possibility is that natural phenomena have somehow kept intelligent life in check. Despite a name that conjures up a cozy dairy bar, the Milky Way is neither a particularly tranquil nor hospitable place. High-energy cosmic rays stream through space in all directions. Fiery explosions pop off at any given moment, and collisions constantly occur at the smallest to biggest scales. Since Fermi's paradox applies to the galaxy as a whole, it's worth

Steve Nadis *is a frequent* Astronomy *contributor who lives in Cambridge, Massachusetts.*

gallery?



A COSMIC BLAST in Earth's near vicinity would do irreversible damage, from severe ozone destruction to a thick cover of toxic gas to global cooling. LYNETTE COOK



MASSIVE STARS EXPLODE in fantastic style. Supernova remnant Cassiopeia A is one stunning example in this composite X-ray (blue and green), visible (yellow), and infrared (red) image. X RAY: NASA/CXC/SAO; OPTICAL: NASA/STScI; INFRARED: NASA/JPL-CALTECH

contemplating astrophysical explanations. Violent events like gamma-ray bursts (GRBs) and supernova blasts might influence biology. Maybe it's so quiet out there because the galaxy has been bathed in all that radiation.

Earth in the crosshairs

In 1999, Fermilab astrophysicist James Annis suggested GRBs might indeed be the answer to Fermi's paradox. According to Annis, if theories linking GRBs with the deaths of massive stars are correct, GRBs occurred more often early in the galaxy's history, when star formation was in full bloom. Perhaps these detonations, and the radiation associated with them, were frequent enough to prevent intelligent life from establishing itself.

Star formation and its accompanying GRBs are now less frequent. The interval between such outbursts is, on average, less than the 100 to 200 million years scientists estimate is needed for intelligent beings to emerge and colonize the Milky Way. If this idea is correct, a "phase transition" may be underway with intelligence, of whatever form, gradually sweeping across the galaxy. Leave a light on — the aliens are on the way.

It's hard to say how farfetched, or plausible, that scenario is, but it's clear that GRBs could pose challenges to developing life-forms. In fact, a team of researchers from the University of Kansas, Lawrence, and NASA's Goddard Space Flight Center in Greenbelt, Maryland, now propose that, 440 million years ago, a GRB some 6,500 light-years (2 kiloparsecs) from Earth initiated the second-largest mass extinction in our planet's history. During the End Ordovician extinction, 70 percent of all marine species — the predominant life-form at the time — perished.

"This extinction has always been a mystery," says University of Kansas paleontologist Bruce Lieberman. "It's traditionally been associated with glaciation, but glaciation doesn't normally lead to mass extinction. If glaciation caused the extinction, what caused the glaciation?"

A 10-second burst of gamma rays from a nearby GRB, the team speculates, would dissociate nitrogen and oxygen molecules in the Earth's stratosphere, leading to the formation of nitrogen dioxide. A chain of chemical reactions would cover the planet in smog, which would absorb sunlight and trigger

THE DRAKE EQUATION

The Fermi paradox asks where extraterrestrial civilizations are, but another component is how many such civilizations are out there. In 1961, Frank Drake of the National Radio Astronomy Observatory in Green Bank, West Virginia, came up with an equation to estimate the number of technological civilizations in our galaxy. The Drake Equation, named after its founder, has seven variables to consider, only one of which is fairly well understood. The equation states

$$N = R^* \times F_P \times N_E \times f_l \times f_i \times f_c \times L$$

where **N** is the number of extraterrestrial civilizations in our galaxy that we can communicate with
R^* is the rate of star formation in our galaxy
F_P is the fraction of those stars that have planetary systems
N_E is the average number of planets around those stars with an environment suitable for life
f_l is the fraction of the above that actually develops life
f_i is the fraction of the above on which intelligent life emerges
f_c is the fraction that is willing and able to communicate
L is the expected lifetime of such a civilization

Astronomers know the rate of star formation is close to 10 per year, but beyond that, our understanding of each value decreases. We are evidence that N must equal at least 1. — *Liz Kruesi*

ONLINE EXTRA How many technological civilizations do you think exist in our galaxy? Try using different values in the Drake Equation at www.astronomy.com/toc

an ice age (see "How a gamma-ray burst would affect Earth," pages 38-39). The nitrogen dioxide may cause the climate to cool, notes team member Brian Thomas, now of Washburn University. "The climate is basically [chaotic], so if you push it in one direction, you can get a prolonged shift."

Atmospheric bombardment by gamma rays will also produce the ozone-destroying nitric oxide. Calculations by Thomas and his colleagues forecast a 55-percent ozone depletion in some latitudes, and a 35-percent loss globally, which would expose organisms to harmful ultraviolet radiation. Creatures at the ocean's surface would receive lethal doses, whereas deeper-dwelling ones, shielded by the water column, would survive — exactly the pattern seen in fossils of small marine animals called trilobites. Trilobite larvae that floated near the surface, owing to their buoyant shells, were annihilated in the End Ordovician extinction, whereas bottom-dwelling larvae fared better.

Were we hit?

So far, the patterns seem to fit, claims University of Kansas astronomer Adrian Melott, but the evidence is far from conclusive. First of all, there's no "smoking gun" — no prospect of finding the GRB remnant 440 million years later. That's because the galaxy rotates every 250 million years, and not as a solid disk. "Stars at different radii rotate at different speeds, plus individual stars have their own random motions," Melott explains. After two rotations, the galaxy becomes "hopelessly scrambled," leaving no trace of the astronomical source.

Second, no GRB debris has ever been detected on Earth comparable to, say, the iridium layer found at the Cretacious-Tertiary (K-T) boundary — evidence of an asteroid impact 65 million years ago that wiped out the dinosaurs and half of all other species. Finding such a signature will be difficult, involving measurements of minute quantities of long-lived radioisotopes like plutonium-244, but perhaps not impossible.

Stanford Woosley, an astrophysicist at the University of California, Santa Cruz, acknowledges that a GRB could, in principle, transport material directly to Earth, provided it were close enough and one of its radiation beams was pointed our way.

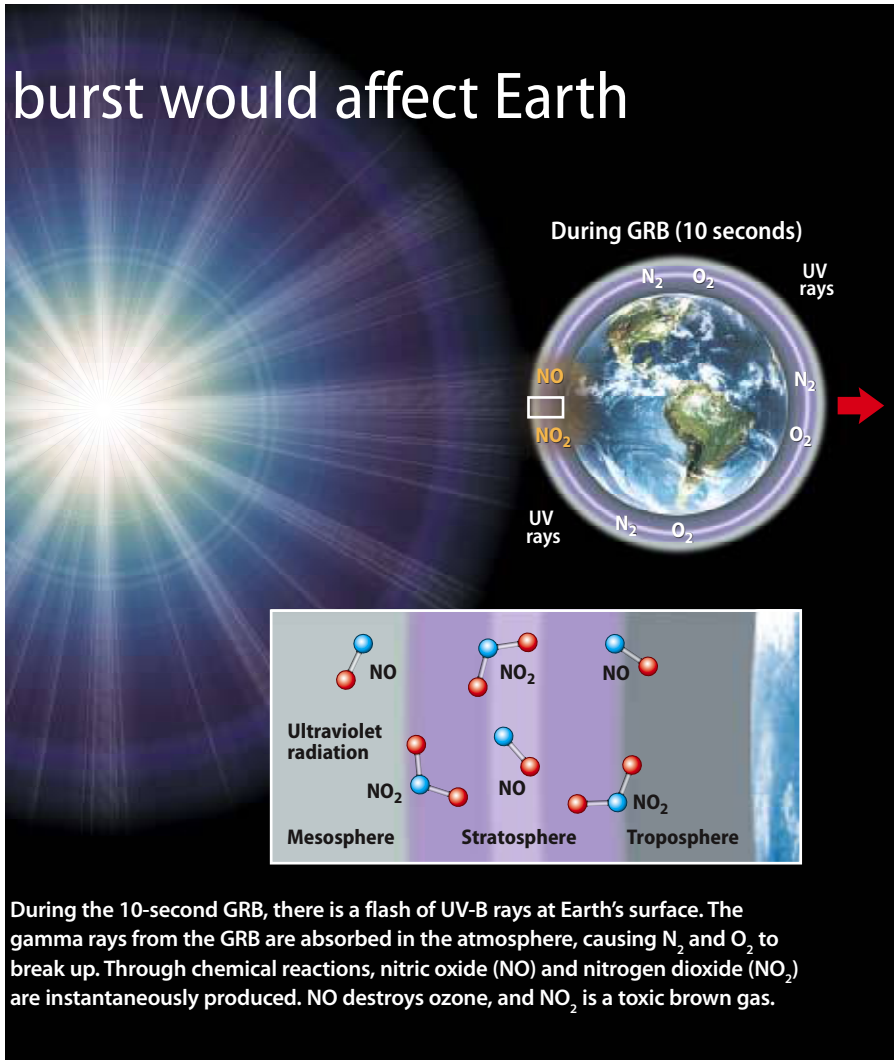
Yet another possibility is that natural phenomena have somehow kept intelligent life in check.

Drive-by shooting

GRBs aren't the only cosmic blasts that could cause damage to Earth. Supernovae, if close enough, could be just as harmful to us.

What's more, there's rock-hard evidence our planet has been affected by at least one nearby supernova. Just a few years ago, Klaus Knie and his colleagues at the Technical University in Munich, Germany, found significant concentrations of iron-60 in rocky crusts beneath the Pacific Ocean. The fact that the iron-60 is still radioactive guarantees an extraterrestrial source, notes Brian Fields, an astrophysicist at the University of Illinois, Urbana-Champaign. With a half-life of about 1.5 million years, any iron-60 included in the formation of Earth would have decayed within a few million years and would be long gone, which means the rare metal must have been deposited more recently — most likely as fallout from a supernova blast.

Judging from the rock layers from which the iron was isolated, the German researchers estimated that the supernova



During the 10-second GRB, there is a flash of UV-B rays at Earth's surface. The gamma rays from the GRB are absorbed in the atmosphere, causing N_2 and O_2 to break up. Through chemical reactions, nitric oxide (NO) and nitrogen dioxide (NO_2) are instantaneously produced. NO destroys ozone, and NO_2 is a toxic brown gas.

went off 2.8 million years ago at a distance of 100 to 200 light-years. The enhanced cosmic-ray flux resulting from that blast, Knie speculates, may have hastened cloud formation, triggering global cooling and a mini-extinction that, in turn, influenced human evolution.

As for the source of this supernova, investigators point to an area of young stars known as the Lower Centaurus Crux group, which made its closest approach to us about 2.5 million years ago. "We think that six supernovae in this group came within [a few hundred] light-years of Earth, though only one is needed to produce the iron-60 deposit," says Jesus Maiz-Appellaniz of the Space Telescope Science Institute in Baltimore. One of those six supernovae, he adds, is the most likely source of the iron-60.

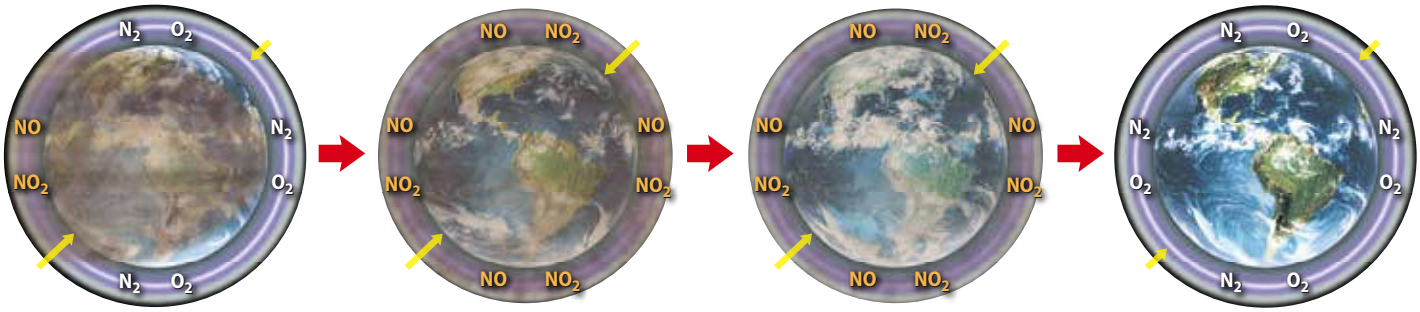
Confirming this claim will take a more accurate determination of the supernova's distance, according to John Ellis, a physicist at CERN in Geneva. The distance calculation hinges on supernova models that make different predictions for the total amount of material, and the relative amounts of different elements, spewed from such a blast. Researchers need accurate concentration measurements for other elements, such as beryllium-10 or aluminum-26, in order to pick the right supernova model to use and thereby calculate the distance. Even so, the iron-60 deposits represent "the first remnants found on Earth of a specific event outside the solar system and the first hard evidence that the solar system is not isolated," says Ellis.

"The fact that there was one such event just a few million years ago suggests there could have been one in the past of even greater significance, and there could also be one in the future," he adds. "So, you might consider this sort of a wake-up call."

In 1993, Ellis and the late David Schramm from the University of Chicago calculated the impacts of a supernova explosion 30 light-years from Earth. The effects they detailed — ozone destruction and mass extinction — are similar to those anticipated for the

> **"We've only** been monitoring solar storms for a few decades, and it's almost certain we haven't seen the biggest event yet."
> — *John Scalo*

IF A TYPICAL GAMMA-RAY BURST (GRB)



GRB blast hypothetically linked to the end of the Ordovician period. The hard part comes in trying to gauge the magnitude of this extraterrestrial threat.

Lethal weapon? Not so much

It's likely that one nearby supernova and one nearby GRB went off in the last billion years, notes Neil Gehrels of the NASA Goddard Space Flight Center. But it would be a stretch to tie all or even most mass extinctions to such energetic events. "The rates are not high enough to prevent life from evolving to a very sophisticated level," Gehrels says. "Our planet is an example: Life has been developing for billions of years, and there's been no cataclysmic event that's wiped out life overall." As for an answer to the Fermi paradox, he adds, "We don't know enough dangerous phenomena to explain the lack of detection of alien life."

Melott agrees that neither GRBs nor supernovae appear to be a "Fermi paradox solver." A nearby explosion would certainly be damaging, he says, "but not likely to kill 100 percent of life, nor render the planet uninhabitable."

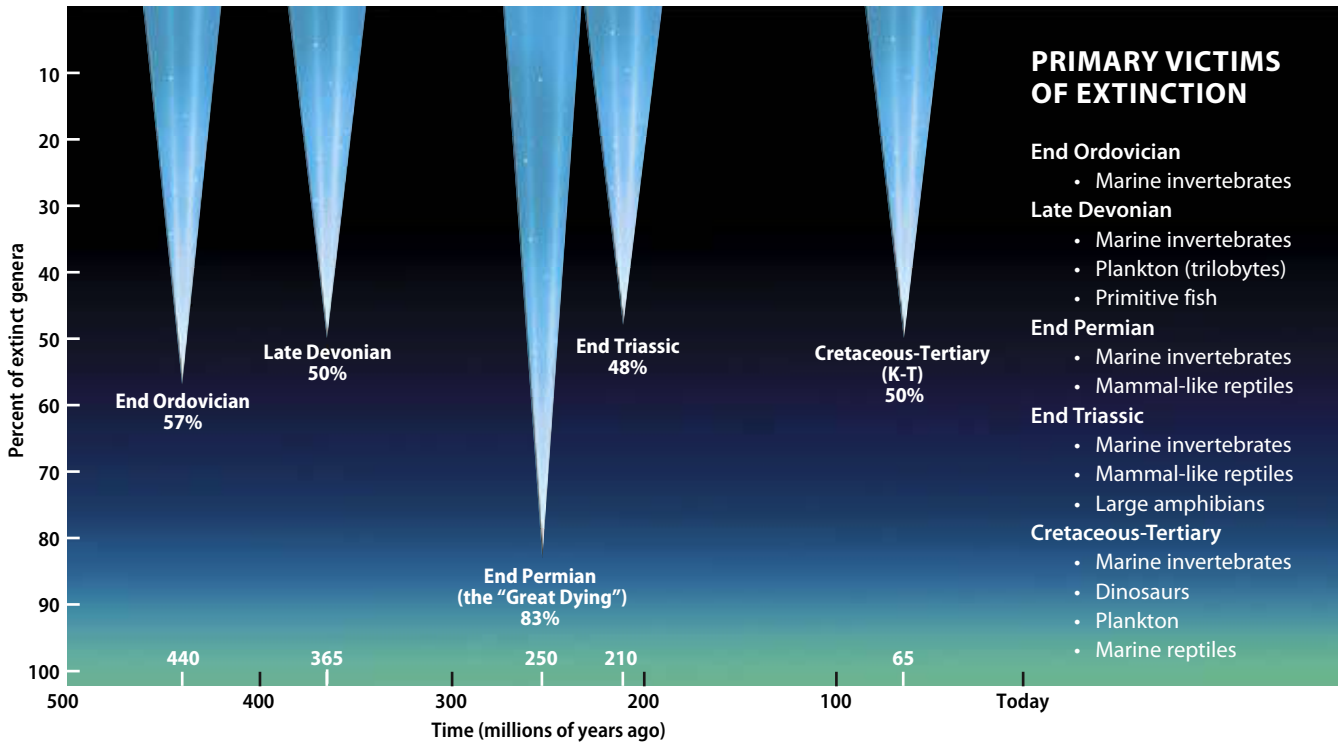
So, what's his answer to Fermi? Once a civilization starts developing high technology, "You start making silly mistakes — like the destruction of the ozone layer — and eventually those mistakes do you in."

Woosley says he's "tired of GRBs being thought of as weapons of mass destruction," and takes a similar view: "We pose a greater danger to ourselves than GRBs do."

Cosmic blasts aren't everything

Six years after his paper was published, Annis now concedes neither GRBs nor supernovae are capable of biological "suppression" on their own. Yet, he's not willing to jettison his idea, which he considers better than other explanations he's heard for the Fermi paradox. He finds the alternative — that Earth is the only place where intelligent life resides — unpalatable: "I just don't buy it. Every time we thought we were the center of the universe, every time we thought we were special, it turned out to be untrue." His theory, nevertheless, lacks a key ingredient — an astrophysical mechanism. In that sense, Annis compares it to inflation. "Our universe looks like inflation occurred; we just don't know what's causing it."

To salvage his idea, scientists need to find a catastrophic event, tied to the star-formation rate, that diminishes in frequency over time, yet repeats itself every 100 million years — the time scientists estimate it would take extraterrestrials to diffuse through the galaxy. GRBs and supernovae could be part of the story, but there may be other energetic phenomena we don't know about. That's not so hard to swallow, considering



LIFE ON EARTH experienced several mass extinctions. The "Big Five" are shown here with the percent of genera that died off. Paleontologists use genera (the rank above species and below family) to gauge extinctions because the numbers are better surveyed. The End Permian event was the worst of the Big Five, with 83 percent of genera going extinct, including 95 percent of marine species. Because the dinosaurs died out during the Cretaceous-Tertiary (K-T) extinction, this is the best known, and most studied. The cause of each mass extinction is still not understood, although scientists are all but certain the K-T extinction was associated with a meteor impact. Astronomers speculate a nearby GRB might have caused the End Ordovician extinction by triggering an ice age.

GRBs weren't discovered until the late 1960s, when their signals were accidentally picked up by military satellites.

Another graphic reminder that danger may be lurking in the neighborhood, unbeknownst to us, came December 27, 2004. On a day when many people were returning holiday gifts, a highly magnetized neutron star called a soft gamma-ray repeater (SGR) emitted the brightest flash of light ever seen outside the solar system, unleashing as much energy in a fifth of a second as the Sun emits in 250,000 years.

SGR 1806-20 is one of just three SGRs known to produce giant flares since the phenomenon was documented in 1979. The December 27 outburst was by far the biggest on record. "Had this happened within 10 light-years of us, it would have severely damaged our atmosphere," notes Bryan Gaensler of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. Fortunately, the star was 50,000 light-years from Earth.

Searching for other explanations

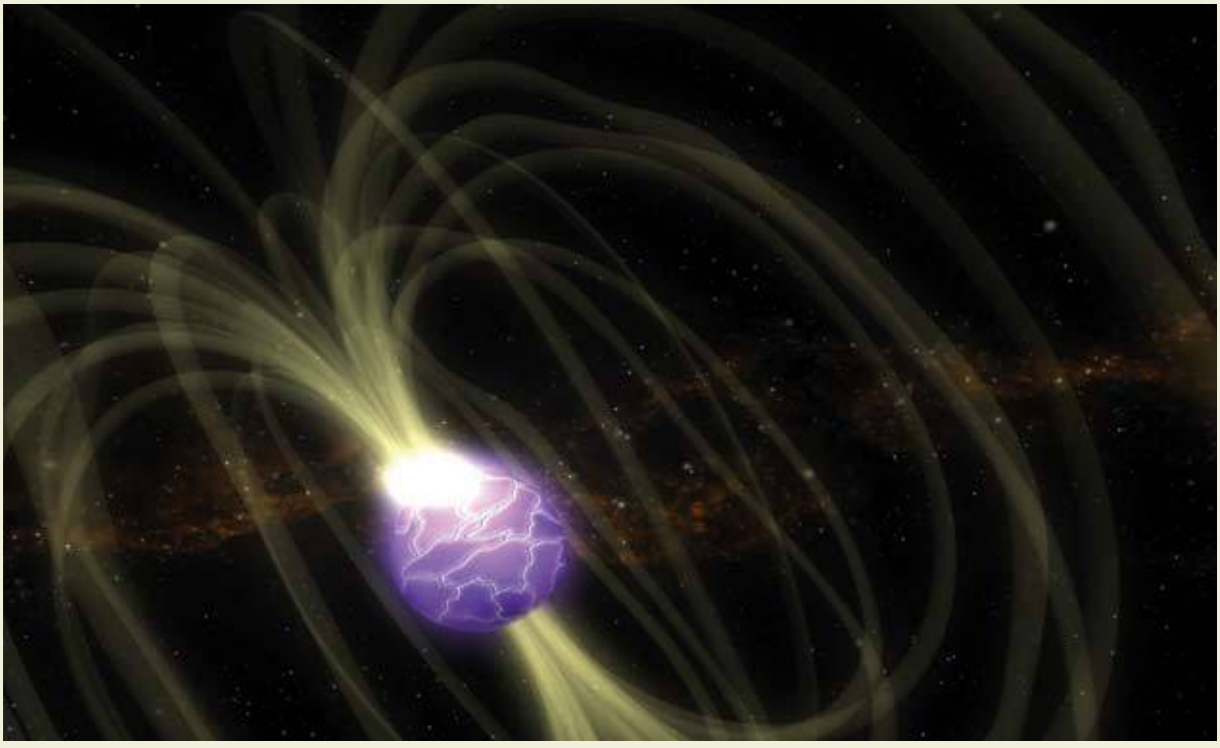
When University of Texas, Austin, astronomer John Scalo began studying how the radiation background influences life, he was initially drawn to the usual suspects — gigantic explosions like GRBs and supernovae. But Scalo now believes flares from a parent star can have a greater influence on life.

Stellar flares are closer and occur more frequently, making them dangerous sources of radiation.

As an example, he points to the solar flares that buffeted Earth for a week around Halloween in 2003, disrupting satellite communications and causing space-station astronauts to seek cover. Solar cosmic rays broke down nitrogen molecules in Earth's atmosphere, prompting the formation of nitrogen oxides that temporarily reduced polar ozone levels by 10 percent. "We've only been monitoring solar storms for a few decades," says Scalo, "and it's almost certain we haven't seen the biggest event yet."

"We can't say for sure they're not here because we've barely explored our solar system." — *Jill Tarter*

While astronomers concede stellar flares could be considerably more devastating than GRBs, owing to their proximity to planets and frequency, Scalo stresses that radiation is not necessarily bad, because it can cause mutations that drive evolution. "When you increase the mutation rate, you increase the diversity of life." For that reason, he believes diverse life might be found on planets



NASA

MAGNETIC FIELD LINES and "hot spots" at SGR 1806-20's polar regions are evident in this illustration. X-ray oscillations viewed by NASA's Swift satellite correspond to the magnetar's 7.56-second revolution.

COSMIC BURSTS PACK A LOT OF PUNCH

On December 27, 2004, astronomers detected the most powerful cosmic burst ever recorded. The blast originated from a highly magnetized neutron star called a magnetar. The star, SGR 1806-20, is on the other side of the galaxy, 50,000 light-years away, in the constellation Sagittarius.

Neutron stars were previously very massive stars. After transitioning through the supernova phase, they are left with the mass equivalent of our Sun in a sphere only 15 miles (24 kilometers) wide. They have highly magnetic fields — a trillion times that of Earth — and rotate at extreme velocities.

Magnetars are neutron stars with magnetic fields 1,000 times stronger than those of ordinary neutron stars. SGR 1806-20 is a member of an even more specific group of objects called soft gamma-ray repeaters (SGRs). These objects occasionally release gamma-ray flashes with a million times more energy than our Sun. There are only four known SGRs: three in our galaxy and one in the Large Magellanic Cloud.

As the intense magnetic fields of the magnetar shifted and reconnected inside the star — imagine an earthquake of magnetic fields — a wave of gamma rays flew away from the magnetar. Radiation hit Earth with such force and energy it distorted Earth's ionosphere (the upper layer of the atmosphere). — *L. K.*

around volatile M stars, which comprise about 90 percent of the galaxy's stars and are famous for their powerful flares. In fact, the California-based SETI (Search for Extraterrestrial Intelligence) Institute hosted a conference in July to discuss the habitability of M stars and the rationale for targeting more of these stars in the search for extraterrestrial life.

If M stars are indeed habitable, and if GRBs, supernovae, and SGRs — or some combination thereof — cannot sterilize vast stretches of the galaxy, how can we answer the question Fermi posed 55 years ago?

The simplest solution to the Fermi paradox is to dismiss it outright. As SETI Institute director of research Jill Tarter explains, "We can't say for sure they're not here because we've barely explored our solar system" — let alone the galaxy. Space is big and mostly empty; the galaxy could be teeming with life, and we wouldn't know about it. We don't have telescopes looking at the sky at all times and in all directions, which means we could easily miss occasional radio communications sent from afar.

So what's to be done? Do the lack of detections to date imply there's nothing out there at all, and that SETI is, by extension, a complete waste of time? Not at all, counters Tarter: "I don't hold with people who say we shouldn't do this or that because there's nothing to be seen. I'm all for looking. Let's do the experiment and see what we learn."

A single discovery of extraterrestrial intelligence would be enough to dismantle Fermi's longstanding paradox. It would also show the GRB doomsday scenario, as well as similar scenarios, to be wanting, while demonstrating the amazing resilience of life.

The search for diamond worlds

Some extrasolar planets may be made of diamonds — and could survive anything the universe throws at them. /// BY RAY VILLARD

A SUBTERRANEAN DIAMOND LAYER stands exposed by a recent impact on a hypothetical carbon planet. A thin, smoggy atmosphere hides much of the world's tar-like surface from view. LYNETTE COOK

In the 2003 science-fiction film *The Core*, an Earth-burrowing vehicle containing "terranaut" scientists dodges Rhode Island-size diamonds floating in Earth's mantle. As farfetched as this film scenario sounds, our galaxy may contain an entire class of planets having a thick mantle of crystallized carbon — what we know as diamond.

The surface of these hypothesized carbon planets likely would feature a coal-black tarry landscape, perhaps with ceramic-hard outcroppings capable of withstanding blowtorch temperatures. Living up to their thick-skinned nature, carbon-diamond worlds could dwell in some of our galaxy's roughest neighborhoods.

They may be the only planets able to form around neutron stars. They could survive in tight orbits around normal stars, where blistering temperatures would melt ordinary rock. Carbon planets might form around later-generation stars choked with heavier elements near the galaxy's core. In a universe that continues to evolve chemically and grows ever dustier, diamond planets one day might be the most abundant newborn planets around.

Although no "diamond planet" has yet been discovered, theorists have not been shy about exploring the possibilities. At a conference on extrasolar planets last February in Aspen, Colorado, Princeton astronomer Marc Kuchner made the case for diamond worlds. He thinks they may turn up within the next 10 years, as observers discover more and more worlds around neighboring stars.

The solar system as prototype

Astronomers expect to find terrestrial planets around nearby stars by the end of this second decade of exoplanet discoveries. As researchers begin to characterize these planets, they likely will conclude that the interiors of exoplanets are much more complicated and varied than now thought. After all, current theories are based almost exclusively on the solar system's composition.

Our solar system contains essentially three planet types: the bloated, low-density gas giants Jupiter and Saturn; the ice-giants Uranus and Neptune; and the four terrestrial planets Mercury, Venus, Earth, and Mars. These latter solid, rocky bodies are layered, like Jell-O and meringue in a parfait. Each has an iron core surrounded by a shell of lighter rocky material.

Ray Villard *recently collaborated with artist Lynette Cook on* Infinite Worlds: An Illustrated Voyage to Planets beyond Our Sun *(University of California Press, 2005).*

Conventional wisdom holds terrestrial planets agglomerated inside a disk of dust and gas whirling around the Sun 4.5 billion years ago. The dusty disk contained smoke particle-size grains mixed with gases.

These elements were forged in the fusion furnaces inside an earlier generation of stars. Carbon is among the most common dusty byproducts of fusion reactions occurring deep within Sun-like stars near the ends of their lives. Late in such a star's evolution, much of its atmosphere escapes into space, like an untethered hot air balloon. As the expanding outer atmosphere cools, carbon forged in the star's interior through the fusion burning of helium cools to form dust grains. Ejected back into space, these grains make up about 1 percent of interstellar gas clouds.

However, the devil may be in the details of the precise chemical mix that provides raw materials for planets. Earth's mantle consists mostly of silicates. These compounds of silicon and oxygen combined as the circumstellar disk surrounding the proto-Sun cooled.

CARBON PLANETS MAY be the most common type in the galaxy.

Kuchner reasons that with a slightly different chemical mix in a star's protostellar disk, compounds like graphite and carbides would condense out instead of silicates. Such disks might have excess carbon, or be deficient in oxygen. Thus, planets with a relatively high carbon content could elbow-out silicate planets.

A tantalizing clue for this scenario comes from some of the solar system's more innocuous inhabitants — carbonaceous chondrite meteorites. These meteorites look like charcoal pieces. They must have come from carbon-laden asteroids that formed in the protostellar nebula. This means the Sun's disk may have varied chemically, with some carbon pockets. The pockets may have created carbon asteroids, but did not contain enough material to build entire planets.

A pulsar connection?

A likely place to find nearly solid carbon planets would be in orbit around pulsars or massive white dwarfs. So far, astronomers have found two pulsars with planets.

One, cataloged as PSR B1257+12, was discovered by Alex Wolszczan and Dale Frail in 1991 and lies 1,000 light-years away in the constellation Virgo. Two of the system's four planets have masses similar to Earth's, one has the mass of our Moon, and one boasts an asteroid's mass. The second pulsar system, PSR B1620–26, lies in the globular cluster M4 in Scorpius and has a Jupiter-mass planet.

LYNETTE COOK

BLUE LIGHT BATHES the harsh landscape of a planet circling pulsar PSR B1257+12. The pulsar's intense radiation excites ions in the planet's thin atmosphere, causing them to fluoresce. Similarly excited ions form tails behind the more distant planets.

PULSAR HARBORS SOLAR-SYSTEM-SCALE MODEL

The first planets discovered beyond our solar system now stand as the best understood extrasolar system. When Alex Wolszczan and Dale Frail first found a trio of planets circling the pulsar PSR B1257+12 in 1991, astronomers had a hard time believing it. After all, a pulsar forms from the collapsing core of a massive star that ends up as a supernova. No one considered that a nurturing environment for planets, but somehow, nature found a way.

Wolszczan and Frail measured the clock-like radio signals emanating from the pulsar and found tiny, periodic changes — the subtle gravitational signals of planets pulling on the rapidly spinning pulsar. When the two announced their discovery in 1992, they had pinned down three orbiting planets. Now, Wolszczan and Maciej Konacki think they have the whole system mapped out.

The PSR B1257+12 system contains four planets orbiting in a near half-size version of our solar system. The inner three terrestrial planets are spaced in almost the same proportions as Mercury, Venus, and Earth. The newly discovered fourth planet's orbit is about 6 times bigger than the third planet's, which, at the same scale, would place it smack in the middle of the Sun's asteroid belt.

The observations effectively rule out the existence of any more distant, massive planets in that system. The tiny fourth planet, with a mass just one-fifth that of Pluto, may occupy the same outer-boundary position in its system as Pluto does in ours. "Surprisingly, the planetary system around this pulsar resembles our own solar system more than any extrasolar planetary system discovered around a Sun-like star," says Konacki. — *Richard Talcott*

A pulsar is the crushed core of a star that either exploded as a supernova or formed when a white dwarf collapsed. The dynamics of the M4 system suggest the gas-giant planet was captured. The terrestrial planets around PSR B1257+12 must have formed after the fireworks that created the pulsar. But how could that happen?

In 1991 and 1992, Philipp Podsiadlowski, Mario Livio, and their collaborators proposed a post-apocalyptic scenario for planet formation around pulsars and massive white dwarfs. In their model, two white dwarfs merge to form a single body: either an even more massive white dwarf or an object so heavy it collapses into a neutron star.

As the white dwarfs spiral together, tidal forces disintegrate one of them. This creates a disk, similar to the protostellar disk encircling a newborn star. The disk would be carbon-rich because white dwarfs consist mostly of carbon. Planets would coagulate in the disk and consist of almost pure carbon.

"The surfaces of carbon planets may be covered with a layer of long-chain carbon compounds — in other words, something like tar," says Kuchner. These carbon compounds, synthesized photochemically in an atmosphere of carbon monoxide and methane, would rain down onto the surface.

The surface might be bone-dry because carbides would chemically split any water to create carbon monoxide and methane. "Basically, living on this planet would be like living in Los Angeles, with all the smog and asphalt," says Kuchner. The crust would be resistant to the high temperatures in close proximity to the parent star. To see how tough silicon carbide is, take a trip to the local hardware store or car shop. The material is so heat-resistant it is used on all types of cutting and drilling devices, and inside motorcycle engines.

Diamond-studded planets

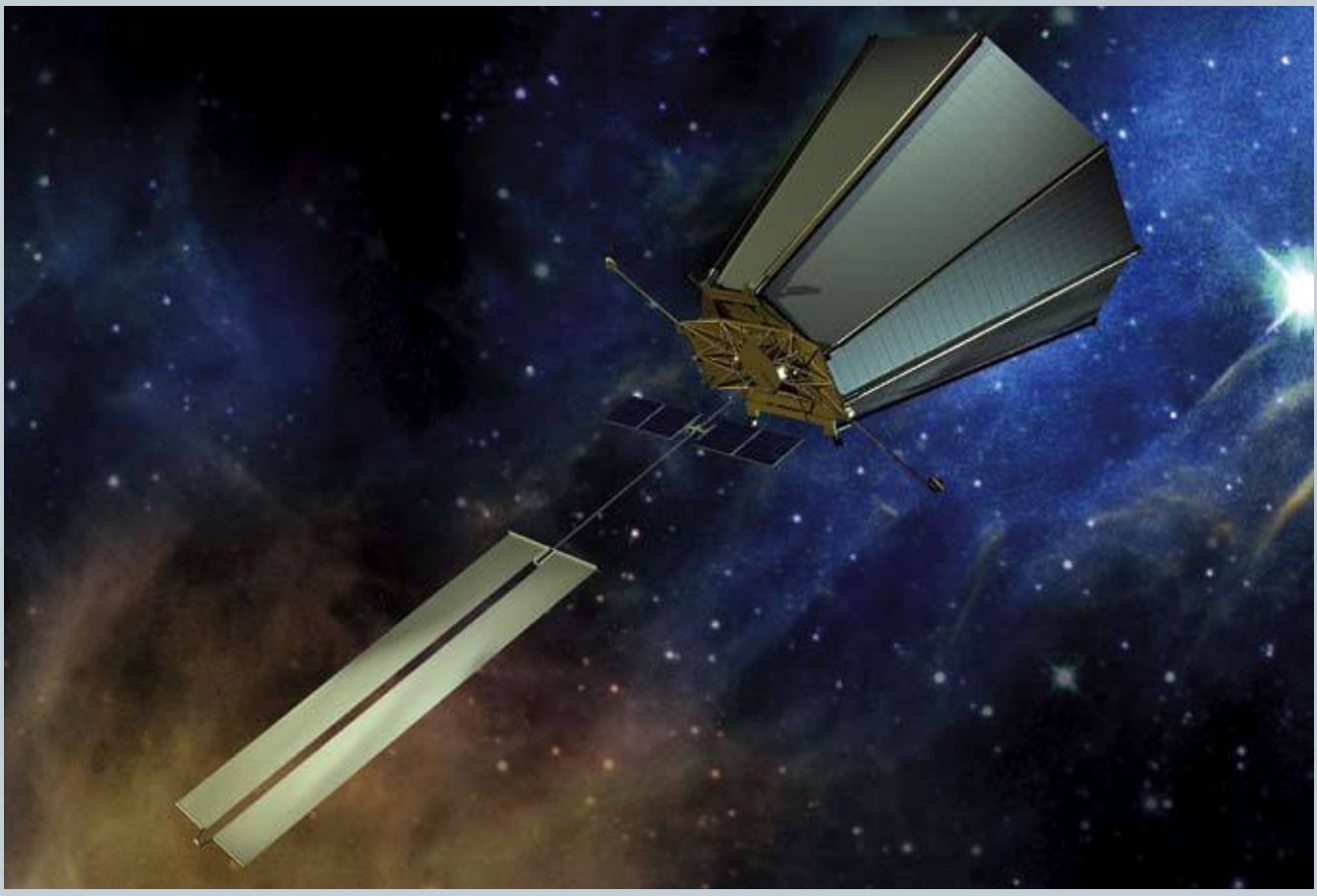
The action beneath the crust would be far more glamorous. One of the universe's most abundant elements, pure carbon, exists in only a few forms. Normally, it is a soft, black solid — the familiar graphite in pencils. Automobile exhaust soot forms "buckyballs," in which 60 carbon atoms link into a hollow sphere. But under great heat and pressure, carbon atoms arrange themselves in a crystalline lattice to become a perfectly transparent, glittering substance harder than anything else found in nature: diamond. Condensed graphite could form diamond layers many miles thick inside a carbon planet.

A novel twist on this idea appeared in Arthur C. Clarke's 1996 science-fiction sequel *3001: The Final Odyssey*. In it, a gigantic diamond mountain ejected from Jupiter's core is found on the moon Europa. This was based on scientific speculation that high temperatures and pressures found inside gas-giant planets might convert methane into diamonds.

In 1999, University of California at Berkeley researchers made diamond dust by squeezing liquid methane to several hundred thousand times the atmospheric pressure at Earth's surface.

It's also conceivable a circumstellar disk around a normal star could precipitate a hybrid planetary system, with a mix of both silicate and carbon planets. This would provide great fodder for science-fiction writers.

Imagine a system where there is a race to fly to a neighboring planet and mine its diamonds. In such a yarn, the diamond planet's inhabitants are happy to barter and believe they're getting the better deal. Diamonds



NASA

ON THE TRAIL OF EARTHLIKE WORLDS

Astronomers have discovered many extrasolar planets — more than 150 since the first were found in 1991. Most weigh 10 or more times what Earth does, a selection effect brought about because the most prolific method for finding planets uses their gravitational influence on their parent stars. The few small planets found to date circle a pulsar, hardly the conditions brought to mind with the word "earthlike."

NASA plans several space-based observatories to search for planets more like Earth. First up is Kepler, which will look for a telltale dip in brightness caused by a planet passing in front of a sample of 100,000 stars. Kepler should fly into space in 2008. A year later, the Space Interferometry Mission will look for tiny wobbles induced by Earth-size planets in the motions of 250 nearby stars.

THE TERRESTRIAL PLANET FINDER will consist of two complementary observatories: this visible-light coronagraph, planned for launch around 2014, and an infrared interferometer scheduled to go up before 2020.

But the ultimate mission will be Terrestrial Planet Finder (TPF) with its two complementary observatories. The first will be a coronagraph that blocks the light of a parent star to look for small planets.

The second will be a suite of infrared telescopes operating as an interferometer. The TPF observatories will gauge the sizes, temperatures, and orbits of planets as small as Earth. TPF's spectroscopes will measure gases like carbon dioxide, methane, ozone, and water vapor to find whether the planets could support life. — *R. T.*

would be so abundant on their world they would be embedded in the granite.

Our galaxy will grow ever richer with carbon as aging solar-type stars process heavier elements and spew them into space. Eventually, several tens of billions of years from now, carbon planets may be the most common type of terrestrial planet in the galaxy. But could they support life?

"Cook it with ultraviolet light from a star over billions of years and almost anything might arise," says Kuchner. The availability of water could pose a problem, but under certain conditions, it might exist. Or, there could be hydrocarbon oceans.

The gooey chemistry of life could be miles-deep on such worlds and would be exotic by our standards. There might be creatures that eat silicates or oxides, and use carbon instead of oxygen for metabolism.

In future exoplanet searches, carbon planets might be identified spectroscopically with optical and infrared space telescopes. This might be accomplished first through transit observations, where researchers would sample a planet's atmosphere and find an abundance of carbon monoxide instead of water vapor.

If such a planet is discovered, baby-boomer astronomers might nickname it "Lucy," after the 1967 Beatles classic song "Lucy in the Sky with Diamonds."

Of course, a cover band would change the lyrics: "Picture yourself on a methane river, with tarry black mountains and carbon monoxide skies."

ONLINE EXTRA Get the lowdown on the known exoplanets at www.astronomy.com/toc

As far as Hubble can see

Astronomer **Sangeeta Malhotra** provides an insider's look at the Hubble Ultra Deep Field.

Last year, astronomers at the Space Science Telescope Institute in Baltimore revealed the Hubble Space Telescope's Ultra Deep Field (HUDF), a million-second exposure that revealed the faintest objects ever seen.

To an astronomer, the term "deep" usually refers to the faintness of objects detected during an observation: A deeper observation detects fainter objects. But the word "deep" also has a more literal meaning. It implies knowledge of distances in the third dimension, as in "How deep is this lake?" Such information is not easily obtainable from astronomical images. Yet, thanks to a Hubble observing program called the Grism ACS Program for Extragalactic Science (GRAPES), my colleagues and I have been able to provide exactly that for the HUDF.

The first step in measuring distance is to get spectra — to split the light from stars, nebulae, and galaxies into discrete wavelengths, like sunlight separated into rainbow colors by a prism or a raindrop. When examined closely, the light often shows breaks or sharp lines. Due to the expansion of the universe, spectral lines shift farther toward the red the more distant a galaxy is, a phenomenon discovered by Edwin Hubble. Astronomers determine distance by comparing redshifts of the same spectral lines in nearby and distant galaxies. It's fitting, then, that we're able to measure the distances of some of the faintest and farthest galaxies using the telescope named for Hubble.

Why is the Hubble Space Telescope so sensitive? Even the largest ground-based telescopes suffer from image-blurring from small motions in Earth's atmosphere. From its orbital perch, Hubble takes sharper images and can resolve small, distant galaxies. Another less well-known advantage of Hubble's location is that our atmosphere glows at red and infrared wavelengths. Yet, distant galaxies are brightest in these wavelengths because intervening intergalactic matter absorbs the other colors.

Sangeeta Malhotra, *an astronomer at the Space Telescope Science Institute in Baltimore, is the principal investigator for GRAPES.*

Sounding the Ultra Deep Field

Two years ago, all of Hubble's strengths came together in a project to carry out spectroscopy of the Ultra Deep Field. Imaging the region using the Advanced Camera for Surveys (ACS) and the Near Infrared Camera and Multi-

MORE THAN 10,000 galaxies inhabit the Hubble Ultra Deep Field. The space telescope's accumulated observations of this 3-arcminute-square patch in the constellation Fornax amounts to a million-second exposure. The image is centered at R.A. 3h32m40.0s, Dec. –27°48'. This cosmic snapshot is at the very limit of Hubble's vision. More distant galaxies, glowing at long infrared wavelengths, are beyond the reach of the telescope's present instruments.

NASA/ESA/STScI/ STEVEN BECKWITH

HUDF in-depth

OBJECTS WITHIN THE HUBBLE ULTRA DEEP FIELD range from stars in our own neighborhood to the most distant galaxy with a directly measured redshift (6.7). Astronomers express distances in the far universe using redshift because it's the most easily determined distance indicator. The preferred alternative is to express extreme distances in terms of the universe's age. IMAGES COURTESY NASA/ESA/STScI/STEVEN BECKWITH AND SANGEETA MALHOTRA

The nearest star in HUDF is known as UDF 366, an M-type dwarf star just 2,000 light-years away.

The farthest star resolved is UDF 2457, another M dwarf. It lies 59,000 light-years away.

UDF 1344 is a star-forming galaxy at redshift 0.0369 (504 million light-years away).

UDF 8316 (center) is an elliptical galaxy at redshift 0.62. Its light took 5.8 billion years to reach us.

UDF 7556, a spiral at redshift 0.89 (6.1 billion years after the Big Bang), is making a lot of stars.

UDF 521 sparkles with newborn stars at redshift 1 — 5.7 billion years after the Big Bang.

This majestic spiral (UDF 423) whirls at redshift 1, when the universe was 43 percent its present age.

We view UDF 1446 at redshift 2.47, as it was when the universe was 2.6 billion years old.

UDF 2881 is a Lyman-break galaxy at redshift 4.6, or 1.3 billion years after the Big Bang.

UDF 5225 is a galaxy with a tail at redshift 5.2, or about 1.1 billion years after the Big Bang.

UDF 2225 is the brightest galaxy at redshift 5.8, when the cosmos was 940 million years old.

UDF 30591 (red dot) is a Lyman-break galaxy at redshift 6.7 — the farthest directly measured.

Object Spectrometer (NICMOS) took about a month of telescope time spread between September 2003 and January 2004. As part of the GRAPES project, my team performed spectroscopy on the HUDF target region between October 2002 and Januay 2003, using abR 10 prcent of the time that went into imaging.

We quickly discovered that GRAPES is not just an extragalactic survey, for the HUDF distance scale starts within our own galaxy. The closest object we have identified, an M-type dwarf star we designated Ultra Deep Field (UDF) 366, lies 2,000 light-years away, stil in our galaxy's disk.

Most of the stars we detected are low-mass M dwarfs, which are both faint and numerous. We can't use redshifts to determine distances to these stars. Instead, we examine spectral features to help us identify their type and luminosity. Then, we figure distance by comparing the brightness we expect to what we actually

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Just 40 hours of Hubble observations have taken us back 12.6 billion years.

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observe. It's a tricky business, employing many indirect arguments.

Next in the HUDF distance scale come small, blue galaxies actively forming stars and bearing a resemblance to nearby dwarf irregular galaxies. The ACS grism (a cross between a diffraction grating and a prism, used for separating light into its component colors) reveals prominent emission lines caused by gas heated and ionized by active star formation. The median distance of these galaxies is 6 billion light-years, so we see them when the universe was half its present age. This was the peak era of star formation. Since then, galaxies have slackened their pace.

At similar distances, we also see massive elliptical galaxies. Sometime in the previous billion years, their star formation halted, so their stellar population skews old. Looking back another 3 billion years and more, the abundance of these old systems was a surprise. They formed quickly in the universe's first couple of billion years and then

stopped making new stars. We hope investigating these galaxies will lead to an insight into what prompts the onset of star formation in a galaxy — and what ultimately stops it.

Farscape

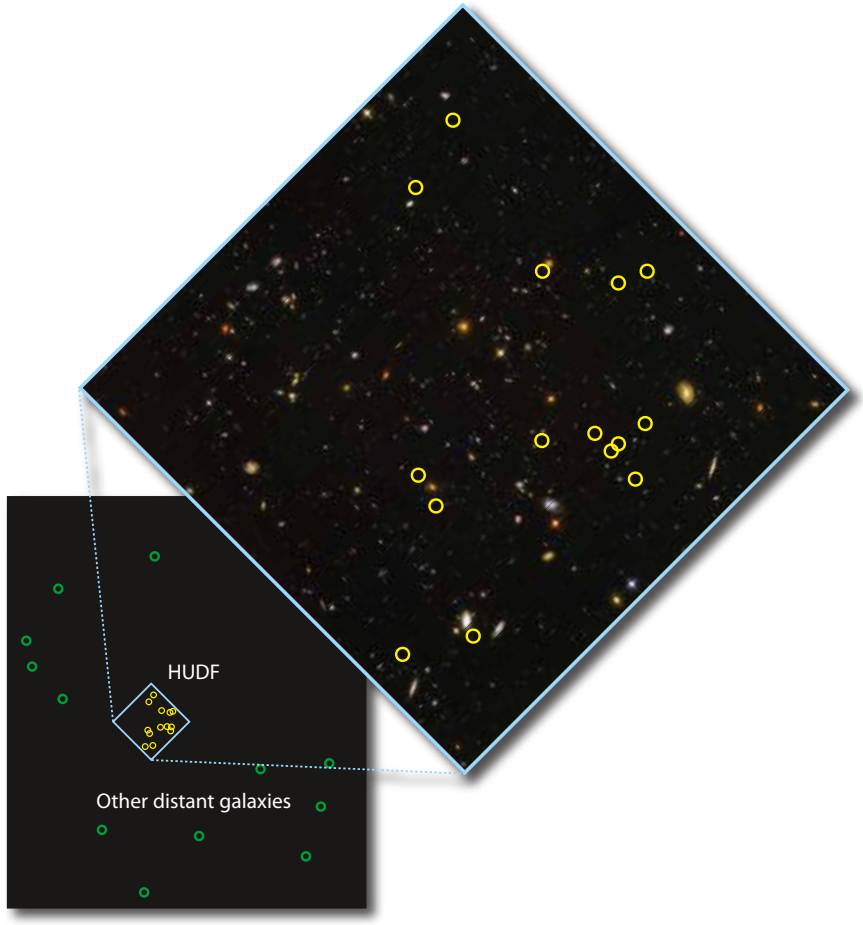
Beyond redshifts of 4 — corresponding to times earlier than about 1.5 billion years after the Big Bang — we can measure the distances of all galaxies thanks to a dramatic drop-off in the ultraviolet spectrum of hydrogen known as the "Lyman break." At such extreme distances, this spectral feature redshifts into the wavelength range ACS can detect. We see about 50 Lyman-break galaxies between redshifts of 4 and 7. And because the HUDF goes deep, we know these are the typical galaxies at those redshifts.

Looking at the colors of these galaxies tells us their stars are younger than those we see in galaxies at intermediate distances. The distant galaxies are ragged and irregular. This is partly because we're seeing them in ultraviolet light, and partly because the galaxies are still forming. Untangling the two effects will be valuable.

Because their spectra give us accurate distances, we can see that these galaxies are distributed in clusters all the way out to the highest redshift visible. For example, one cluster, or "wall," of galaxies lies at a distance of 6 billion light-years (redshift 0.67). Old, elliptical galaxies dominate these dense, high-redshift regions just as they do the local universe.

Galaxy chains

At about redshift 6, we see another primitive cluster of galaxies. They are among the most distant galaxies, with redshifts as high as 6.7. (In fact, the location for HUDF was selected to include a relatively bright galaxy identified by a previous survey at redshift 5.8.) About two-thirds of the galaxies we find at this redshift occupy a third of the volume, and statistics tell us such a concentration is about 4 times greater than expected by chance. Moreover, the galaxies lie on one side of the Ultra Deep Field, clustering not only along the line of sight, but in the plane of the sky as well.



To see how far this cluster extends, we took wide-field images of the region using Cerro Tololo Inter-American Observatory telescopes near La Serena, Chile. At redshift 5.8, which is accessible from the ground, we see a wall of galaxies spanning at least 20 million light-years — with the HUDF situated right at the edge.

One of the motives for the deepest imaging of this patch of sky was to take a census of galaxies at redshift 6. The light we see left these galaxies within the Big Bang's first billion years. But astronomers remain split on whether these are the first galaxies.

We can find some answers by looking at the diffuse gas surrounding galaxies, rather than at the galaxies themselves. We see the gas has been heated and ionized by energetic ultraviolet light, and there is some evidence that the amount of ionized gas falls off at redshift 6. This could be when galaxies first began forming stars, lighting up the universe for the first time since the Big Bang, ending the so-called Dark Ages.

A census of these galaxies would reveal whether they're the source of the ultraviolet light that ionized intergalactic gas. One group of researchers concluded the HUDF contains only a third of the galaxies needed. Another team claims that, once we take into account faint galaxies that might have been missed, there are enough to do the job. Where these galaxies cluster together, they produce enough ultraviolet light to ionize the surrounding gas. So, in the end, finding enough galaxies to ionize intergalactic gas may depend simply on where astronomers look.

So, how deep is the Hubble Ultra Deep Field? In terms of brightness, it is 1/10 of a million — that is, its brightest object outshines its faintest by 100,000 times.

In terms of distance, HUDF ranges 1/10 of a billion, meaning its nearest and farthest objects are separated by about 100 million times.

And in terms of time, HUDF has given us a glimpse of the universe nearly 800 million years after the Big Bang. Just 40 hours of Hubble observations have taken us back 12.6 billion years. For NASA's budget, that's a lot of Big Bang for the buck.

ONLINE EXTRA Hubble astronomers plan more deep fields. See what's in store at www.astronomy.com/toc

The biggest hole in the

A gigantic impact basin holds the keys to the solar system's past — and may also provide a base for human exploration. /// BY JAMES OBERG

Sixteen-hundred miles wide and nearly 8 miles deep, the South Pole-Aitken basin sprawls across the Moon's southern farside. It's the largest, deepest, and probably the oldest, impact basin in the known solar system.

For scientists, investigating the basin would provide a look into what may be the Moon's mantle, conveniently exposed at the surface. Also, dating the impact that created the feature will nail down a major point in the history of the Earth and Moon system and, by extension, the entire solar system.

For mission planners looking ahead to humankind's return to the Moon and eventual missions to Mars, the South Pole-Aitken basin provides a natural target — one that has a "climate" as benign as any the Moon has to offer. Additional reasons include the possibility of siting radio telescopes near the Moon's south pole, which stands on one edge of the basin.

Finally, there's the possibility of finding water ice in the soil of nearby craters. Besides its scientific attraction, ice could be mined to produce air and fuel for a Moon base.

James Oberg, *a former NASA space engineer specializing in shuttle orbit operations, has been following everyone's space programs for decades.*

Shadows and ice

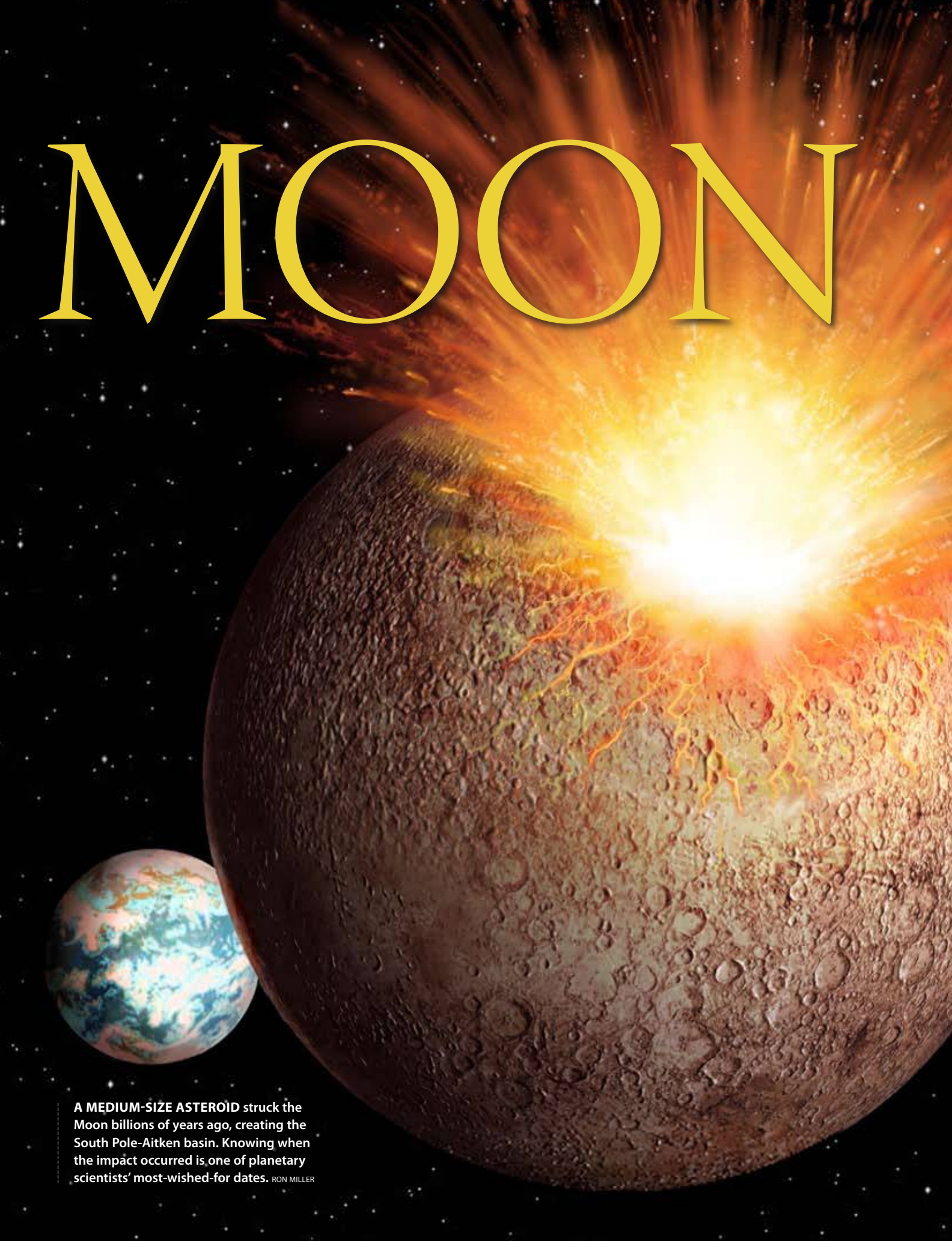
The notion of lunar ice sounds outlandish. Why should the Moon — a world with no atmosphere and whose rocks contain almost no volatile materials, especially water — have any ice at all?

Here's the secret. By a fortuitous coincidence, the Moon's rotation axis tilts only 1.5° to the ecliptic plane, the path of the Earth-Moon system around the Sun. If astronomers' calculations are correct, it has been that way for at least 2 billion years, and perhaps twice as long — right back to the last major impacts that shaped the lunar surface.

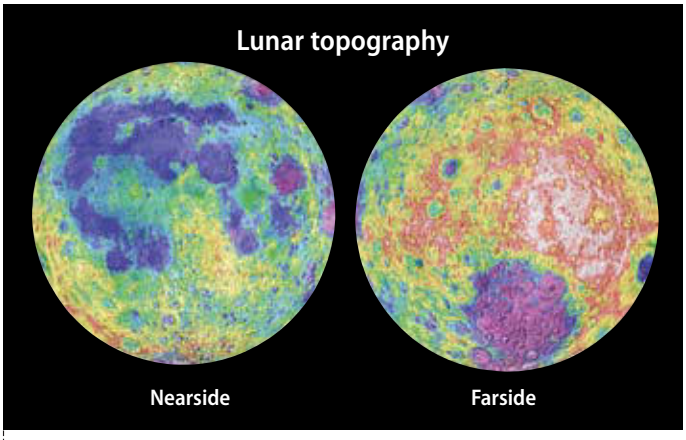
At the Moon's north and south poles, no portion of the half-degree-wide Sun ever rises higher than about 2° above the horizon. This means some craters close to the poles have floors that are eternally in shadow. These should become very cold, with temperatures of –280° Fahrenheit (–173° Celsius) or so.

The cold floors of these craters will trap random molecules of water. The molecules might come from the tails of passing comets, or even comet impacts, which would give the Moon a transient atmosphere loaded with water vapor. Other sources include impacting meteorites with water-rich rock, or even occasional lunar outgassing.

MOON

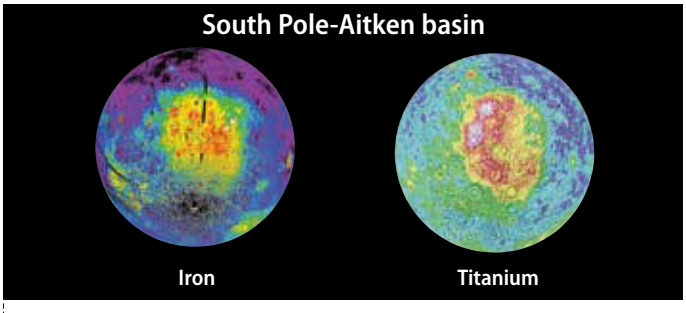


A MEDIUM-SIZE ASTEROID struck the Moon billions of years ago, creating the South Pole-Aitken basin. Knowing when the impact occurred is one of planetary scientists' most-wished-for dates. RON MILLER



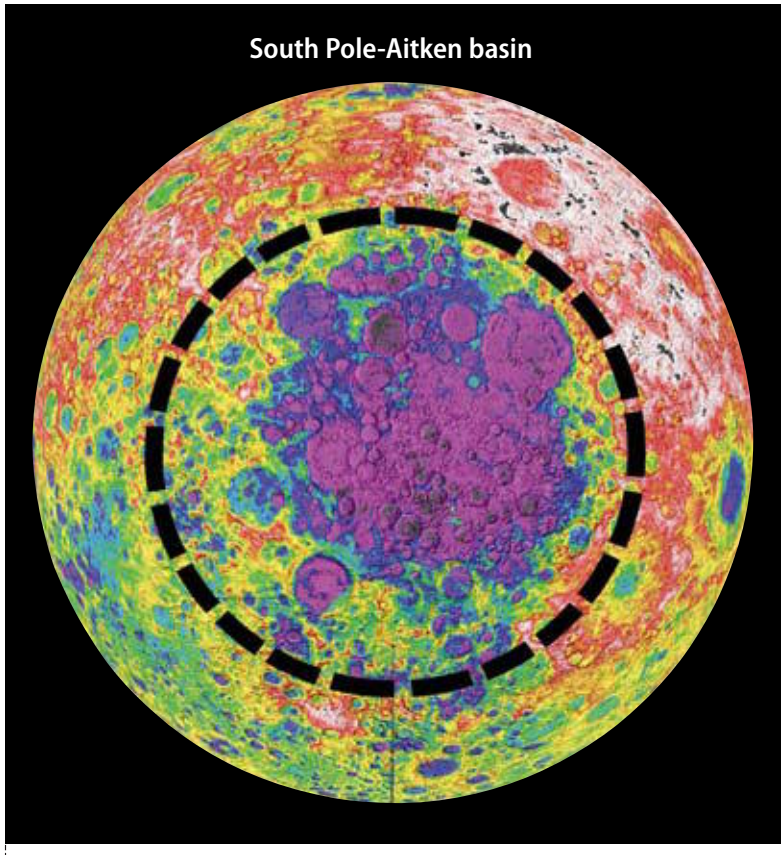
NASA

LAVA FLOWS FILLED many basins on the Moon's nearside. But a 50-percent-thicker crust on the farside made it more difficult for magma to reach the surface. Note the "hole" in the southern farside: the South Pole-Aitken basin.



NASA

IT'S AN ANOMALY, ALL RIGHT. The basin stands out in elemental maps that show abundances of iron and titanium.



ASTRONAUTS CAUGHT GLIMPSES of the South Pole-Aitken basin from orbit, yet remained unaware of what they were seeing. Finally, altitude measurements from the Clementine probe revealed the basin's true size. NASA

Impacts elsewhere on the Moon would redistribute rock and soil and other surface materials, so any ice would be mixed with lots of dirt. And impacts within the ice field itself would gouge out older deposits and throw them atop younger ones.

Until about 10 years ago, lunar ice was all speculation. From Earth, and from the mostly equatorial orbits of the Apollo missions, the Moon's polar regions are literally out of sight. The ice-cap theory couldn't be tested until specially equipped polar-orbiting spacecraft reached the Moon during the 1990s.

Slippery target

Hints of lunar polar ice came in 1996, when radio data from the Clementine probe indicated the wall of a south polar crater was more reflective than expected — and ice was the most likely explanation. The spacecraft took data on four passes over the south pole, and one pass showed an enhanced, tightly beamed backscatter of radio signals, indicating ice. That pass was the only one where the beam included large amounts of permanent darkness, including Shackleton Crater, which is not visible to Earth-based observers.

Two years later, neutron spectrometer data from the Lunar Prospector spacecraft suggested the presence of hydrogen (and by inference, water) about a yard underground at both poles. The observations correlated directly with passes over permanently shaded areas.

But radar astronomers using the Arecibo radio telescope at 12-centimeter wavelengths were skeptical, and remain so.

In 2003, the Arecibo radar probed the floors of two craters in permanent shadow at the lunar south pole, Shoemaker and Faustini. It also examined the floors of Hermite and several small craters within the large crater Peary at the north pole.

"Lunar Prospector found significant concentrations of hydrogen at the lunar poles equivalent to water ice at concentrations of a few percent of the lunar soil," says Bruce Campbell of the Center for Earth and Planetary Studies at the Smithsonian Institution. "There have been suggestions that it may be in the form of thick deposits of ice at some depth, but the new data from Arecibo makes that unlikely," he continues. "There are no places that we have looked at with any of these wavelengths where you see that kind of signature."

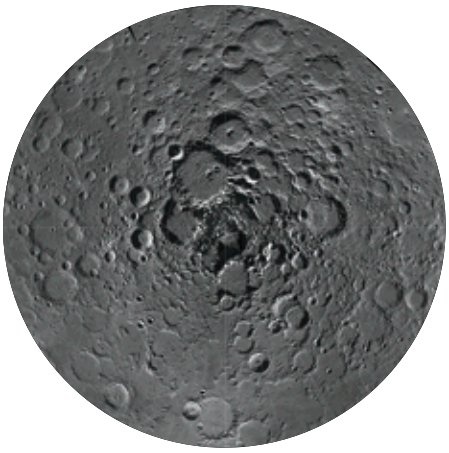
Icy or rough?

Instead, Campbell's team concludes the backscatter it observed is caused by surface roughness, not water ice. But Paul Spudis of the Johns Hopkins University's Applied Physics Laboratory disputes Campbell's interpretation. "In fact, they do detect zones of high backscatter," he says. "They claim it's roughness, not ice. We claim that it's consistent with the idea that it is ice."

The latest radar results, Spudis continues, show the same as earlier Earth-based radar studies, and they are just as susceptible to different interpretations. "We have basically three separate data sets," he explains. "Two show positive for ice and one is ambiguous. Judge for yourself what the answer is."

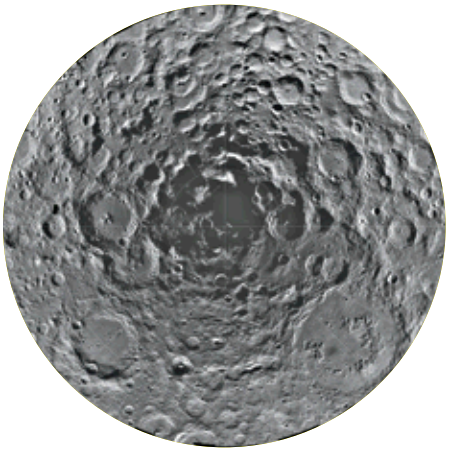
Campbell replies, "If there is ice at the poles, the only way left to test it is to go there

North polar region



CLEMENTINE IMAGES stitched together yield a view of the lunar north pole. The amount of permanently shaded terrain is less in the north than the south. NASA

South polar region



SHADOWS GATHER in south polar craters, many of whose floors never see sunlight. Dropping to temperatures of hundreds of degrees below zero, such cold terrain can trap passing molecules of hydrogen and water. NASA

directly and melt a small volume around the dust and look for water with a mass spectrometer." Spudis agrees that more orbital and lander missions are called for.

If there is any water at all near the lunar poles, Campbell and his colleagues continue, "It is widely scattered and permanently frozen inside the dust layers."

From the resources point of view, says Spudis, "It doesn't matter whether there's ice there or not — there *is* a hydrogen enrichment at the poles."

The form of the hydrogen — either as molecules of H_2 or H_2O — affects only the kind of processing required; it doesn't

/// ROBOTIC MOON MISSIONS

JAXA

AFTER ORBITING THE MOON for a year, the Selene probe will detach its propulsion module, which will make an automated soft landing on the Moon.

MOONWATCHERS

The renewal of scientific interest in the Moon has spurred several countries' development of lunar spacecraft.

SMART-1
- European Space Agency (ESA)
- Launched: September 23, 2003
- Reached Moon: November 15, 2004
- Ion-drive propulsion
- Main instruments: imager, spectrometers
- Chief focus: testing ion drive, studying Moon, looking for polar ice

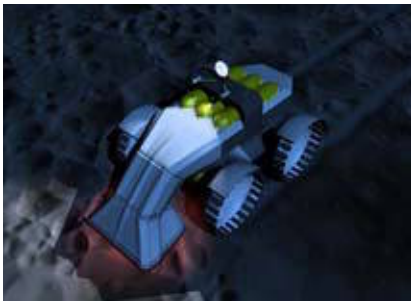
Selene
- Japanese Space Agency (JAXA)
- Launch: 2006
- Reaches Moon: 5 days after launch
- Thruster propulsion
- Main instruments: multi-wavelength imagers, spectrometers
- Chief focus: mapping elemental abundances, mineral composition
- Carries two relay and radio astronomy satellites

Chandrayaan-1
- Indian Space Research Organization (ISRO)
- Launch: September 1, 2007
- Reaches Moon: 5 days after launch
- Thruster propulsion
- Main instruments: terrain-mapping camera, spectrometers
- Chief focus: mineral and chemical survey of polar regions
- May include hard-landing impact probe

Chang'e 1
- China National Space Administration
- Launch: late 2007
- Reach Moon: few days after launch
- Thruster propulsion
- Main instruments: imager, altimeter, spectrometers
- Chief focus: testing technology, studying lunar environment

Lunar-A
- Japanese Space Agency (JAXA)
- Launch: TBA
- Thruster propulsion
- Main instrument: mapping camera
- Chief focus: studying Moon's interior with seismology
- Carries two surface penetrators with seismometers

Lunar Reconnaissance Orbiter
- NASA
- Launch: October 1, 2008
- Reaches Moon: 4 days later
- Thruster propulsion
- Main instruments: high-resolution imager, spectrometers
- Chief focus: looking for water ice, mapping surface in detail



SCOUTING FOR ICE-RICH RUBBLE, a robotic mining rover scavenges the floor of a shadowed crater.

THE ROVER-MINER DELIVERS the scooped-up mixture of ice and lunar soil to an automated refinery.

AT THE REFINERY, liquid oxygen and hydrogen are loaded into a robot tanker (left) for delivery to crews for use as fuel, air, and water.

J. FRASSANITO & ASSOCIATES

THE HYDROGEN TANKER fills a scouting ship's fuel pods in preparation for an exploration trip.

NASA

THE NEXT HUMANS TO GO to the Moon will likely establish manned bases in the polar regions. Such bases could provide access to volatile resources (for example, water ice or hydrogen) trapped in shadowed craters.

change the rationale for going to the poles to establish bases.

The long-term value of such a resource would be profound. Using solar power, water could be broken down into oxygen and hydrogen and stored cryogenically for use as propellant. Water and oxygen are also key components for life-support systems.

But however abundant polar hydrogen is, building Moon-based propellant refineries will require hauling massive amounts of apparatus from Earth to the lunar surface. Therefore, for the first human return to the Moon — and even for early expeditions to Mars — hauling the propellant from Earth may still cost less than first establishing a lunar-based "fuel mine."

The big hole

Looking beyond the immediate south polar region, the big basin remains at the center of attention for new missions. Even with no possibility of polar ice, it would draw much scientific interest.

The region's name, given by Don Wilhelms of the USGS, is a little misleading. "Neither the south pole nor Aitken Crater are actually inside the basin," says Michael Duke of the Colorado School of Mines. "They are simply the two most identifiable surface features that mark the boundary of the structure."

The South Pole-Aitken basin lies just over the limb on the Moon's farside. Heavily cratered by later impacts, it lacks the large, thick floods of dark lava that fill most basins on the nearside, some to overflowing. Thus, South Pole-Aitken appears indistinct when viewed by human eyes. Sheer size also contributes to the vague impression because it's hard to see all of the basin at once.

The existence of a "Big Backside Basin" was suspected as early as 1962, when William K. Hartmann and Gerard Kuiper noted tall mountains at the lunar south pole and thought these might form part of its rim. Other sections of the basin rim were photographed from lunar orbit by the Apollo 8 astronauts in 1968, but the overall picture remained murky.

A decade ago, however, images from the Clementine probe, assembled into mosaics to cover large areas, clearly showed the basin floor is distinct from surrounding terrain — in particular, it appears darker. Laser altimetry also put figures on the basin's gross properties: 1,600 miles (2,600 kilometers) wide and 7.5 miles (12 km) deep.

In Clementine surface-composition maps, the basin stands out prominently. Observations with a later generation of sensors on Lunar Prospector (1998–1999) showed the soil is more iron-rich and slightly more radioactive than the rest of the Moon's surface. It also generally lacks the typical anorthosite minerals retrieved from the nearside by Apollo astronauts.

Scientists want to get their hands — and instruments — on rock samples from South

Pole-Aitken. "Sample return from the basin is one of the highest-priority science missions," wrote a team of lunar scientists in 2003. The mission, they added, comes "second only to Kuiper Belt-Pluto exploration."

Samples should help scientists answer the most fundamental question about the South Pole-Aitken basin: How old is it?

The many craters it bears indicate the basin is quite old. Graham Ryder of the Lunar and Planetary Institute said in 2000 that it may be as young as 3.92 billion years old — still older than all the nearside basins — or as old as 4.3 billion years.

Knowing where the basin's birth falls within that range will help scientists better understand the period called the Late Heavy Bombardment. Debate has raged for decades whether this period belonged to the final stage of planetary formation — or if it was a separate shower of asteroids and giant meteorites caused by some unknown disruptive event.

Probing the rubble

Scientists expect to find the basin full of well-mixed rocks of a type called melt breccia. This results from "gardening" by random impacts over the ages. The samples will include fragments from deep within the Moon's crust, possibly from the upper mantle. Orbital measurements indicate the basin holds minerals not found elsewhere on the Moon's surface. Although lunar geologists estimate about 20 percent of the basin's material comes from elsewhere on the Moon, they are confident they can identify the special local minerals.

The existence of a "Big Backside Basin" was suspected as early as 1962.

Spudis describes the process: "You take a lot of remote-sensing data and learn the properties of the basin floor in a regional sense. That would let you interpret the samples you get as belonging to that unit or not."

The long impact history introduces a lot of room for error. Cautions Spudis, "With a sample from the Moon, you never know if you're really sampling a regional unit or something else. Yes, you can grab samples and probably get pieces of the basin floor. But saying this or that piece comes from the impact melt sheet or is from the lower crust — well, that's more problematical."

He laughs. "We make a landing, we obtain some samples — and then we spend the next 30 years trying to figure out what they're telling us."

Within the basin are some unique features, and geologists want to sample them all — either with rovers or multiple fixed-lander missions. Central peaks of large craters should contain samples from below the basin debris. A feature dubbed Olivine Hill in the central region may be a deposit of the deepest rocks.

Northwest of there, according to Carle Pieters of Brown University, is a thorium anomaly she describes as "an enigma." It may be debris from the Imbrium impact on the exact opposite side of the Moon. Scientists have already mapped and sampled a region adjoining Imbrium that is rich in thorium and other radioactive minerals.

Dating the cataclysm

The first proposed sample-return mission to this area was developed in the late 1990s for NASA's low-cost Discovery program, but it was not selected. The mission would have used a stationary lander with a robotic arm and screening device to collect a pound or two of small rocks and dust.

A relay satellite placed in lunar orbit would have provided less than a week of communications between the lander on the farside and Earth; the lander would have needed to act quickly and then blast off with whatever it had collected.

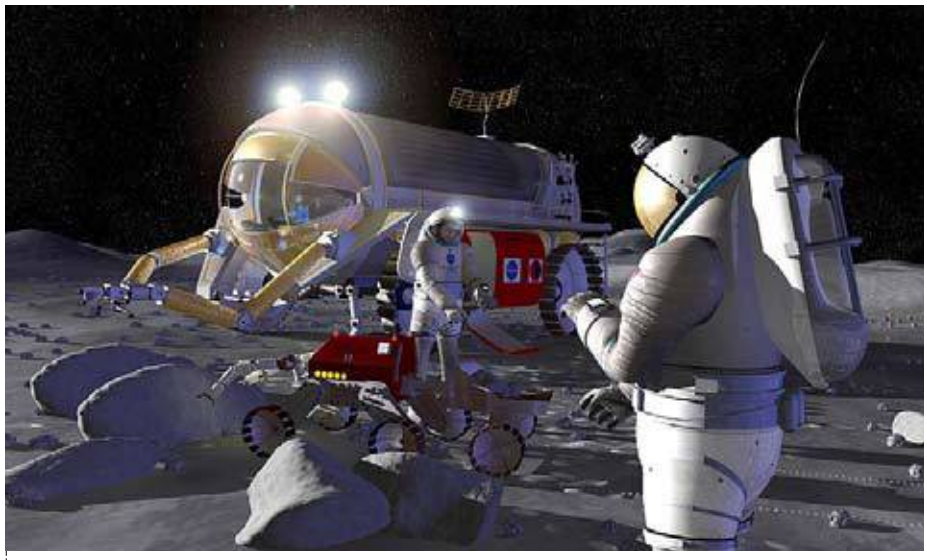
In 2003, another robotic mission called Moonrise, proposed by Colorado School of Mines' Michael Duke, also failed to get the nod under a different NASA program.

As Spudis observes, however, "With a robotic mission, you have a large chance of getting an ambiguous answer. The older the event on the Moon, the less certain you are that a sample you pick up is related to that. And going to the oldest feature on the Moon just magnifies the problem many times over. You can't be sure what you've got — even after you have it."

NASA's renewed emphasis on returning to the Moon may remove some of the hurdles scientists and mission planners have faced. And the possibility of having trained crews on the Moon opens many possibilities for pathbreaking science.

Says Spudis, "If you go back to the Moon permanently and can revisit sites to understand things in their true field context, I think that'll be a whole different ball game." Follow-up work, he notes, is extremely important in terrestrial geology.

"If people go to live at the south pole as part of a human return to the Moon," he says, "I think they'll have a very good chance of unraveling a lot of the South Pole-Aitken mystery." A



J. FRASSANITO & ASSOCIATES

EXPLORING THE MOON will help scientists learn more about the solar system's history and our place within it. It's an essential step in the journey to Mars.

ONLINE EXTRA For more on dating the Moon's early history, go to www.astronomy.com/toc

BY MARTIN RATCLIFFE AND ALISTER LING

November 05

There's more to observe than Mars this month — although the Red Planet certainly deserves the spotlight. Watch Venus and Mercury ply the evening twilight, and see an unstable star's flare-ups.

Mars rules!

The fierce orange "star" rising

in the eastern sky after sunset would have worried our distant ancestors. Shining more brightly than Jupiter, a Mars like this undoubtedly was perceived as a threatening sign from the heavens. Thanks to science and spacecraft visits, the only true message its appearance bears is "watch me." Mars will not be as big and bright again until 2018.

Observers in the northern United States, Canada, and Europe probably will see more surface markings now than they did 2 years ago during Mars' historic apparition, simply because the planet lies much higher in the sky. For more details on Mars' size and what to look for, see "Set your sights on Mars" on page 76.

A word of advice for beginners: patience. As big as Mars appears compared with an average apparition, newcomers will find its dazzling ochre light a tiny, inscrutable disk. Only dedicated observation will allow your brain to tame the fleeting, low-contrast detail.

If you've never seen an asteroid before, Mars presents a nice opportunity by pointing the way to Fortuna. The two aren't close in space, it's just that the asteroid lurks in the background along roughly the same line of sight.

Blazing Venus hangs low in the southwest as twilight deepens. This is as high as it's going to get this year, much lower than it appears during springtime. If you point a small telescope at our sister planet, you will see its phase much as Galileo did almost 400 years ago.

It currently appears like a half-Moon, 50-percent lit. As time goes by, it will show more of a crescent phase. Speaking of crescents, a slender slice of our Moon slides just below Venus the evening of November 5.

If you have a good view of the sky near the true western horizon, try to spy elusive Mercury 30 to 40 minutes after sunset. Scan slowly with binoculars, about four fields of view to the right of Venus.

A razor-thin crescent Moon lies just below Mercury on the 3rd. Follow the innermost planet's path during the next week as it slides past the sparkling, but fainter, orange star Antares.

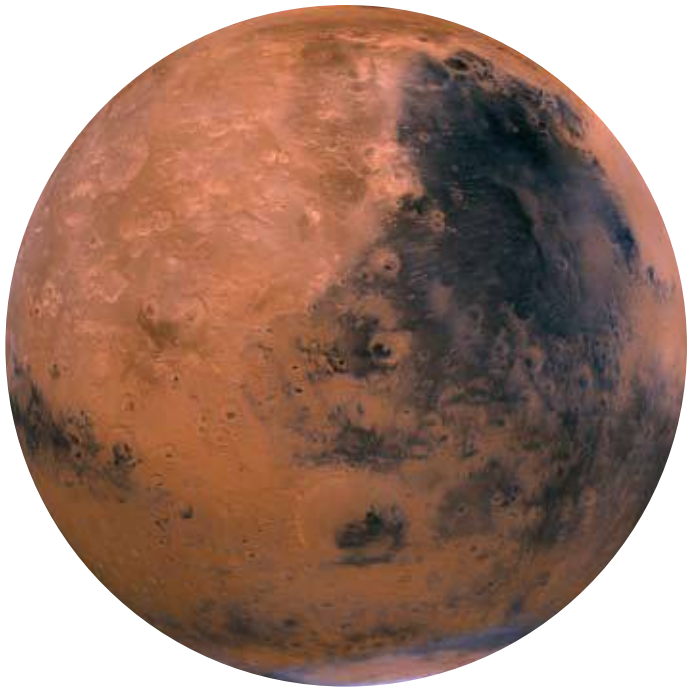
Both disappear into the Sun's glare before mid-November. For lucky observers south of the equator, Venus and Mercury stand much higher, appearing almost straight above the point where the Sun sets.

If you have a digital camera, you'll easily be able to take a sequence of 20 or more equally spaced images of the Moon slipping below and left of Venus the evening of November 6. If you then create a composite image, you can see how the Moon moves to the left even as it sets to the right.

Unless it's cloudy on the 14th, people will comment on the impressive pairing of the Full Moon and Mars as they rise together in the east. When the Moon passes Mars in December, it won't be as full — a nice demonstration that the Moon's orbit around Earth is a couple of days shorter than the 29.5-day lunar-phase cycle.

If you're awake around 6 A.M. November 28, look eastward. Earthshine fills out the lunar crescent, evoking the poetically named "new Moon in the old Moon's arms." Below, Jupiter shines steadily, while the pale-sapphire Spica twinkles to the Moon's upper right.

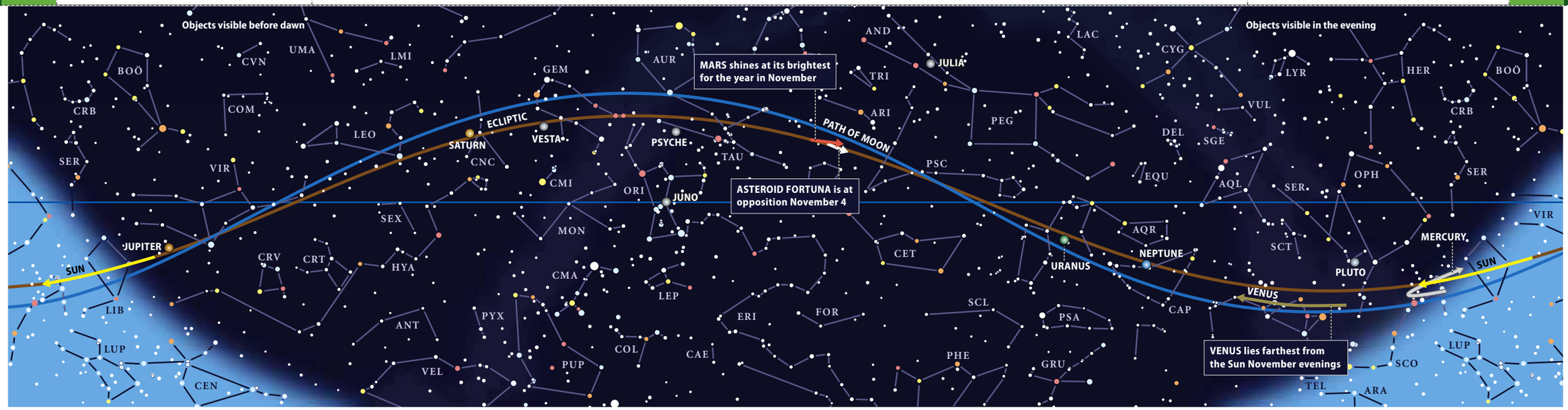
Deep-sky splendors await you far from city lights on the New Moon weekend of November 4 and 5. Whenever you're not looking through the eyepiece or bending over star charts, look up, because you might catch some graceful South Taurid meteors sweeping across the starry vault.



THE RED PLANET GLOWS all night long in November, shining brighter than it will at any time until 2018. NASA/JPL/USGS

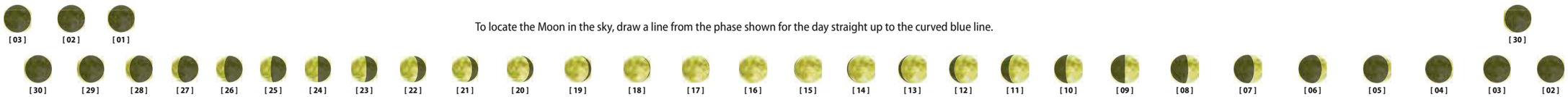
Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.



ALL ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

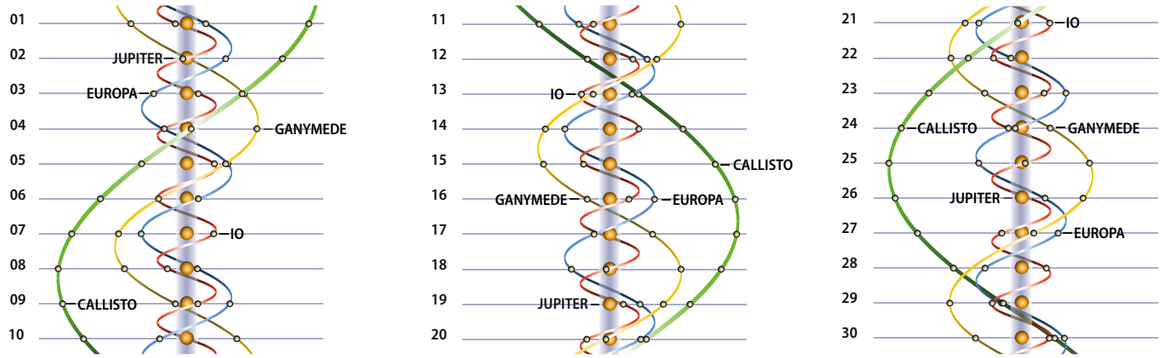
To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.



PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Date	Nov. 1	Nov. 30	Nov. 1	Nov. 30	Nov. 1	Nov. 15	Nov. 15	Nov. 15	Nov. 15	Nov. 15	Nov. 15
Magnitude	−0.3	—	−4.3	−4.6	−2.3	−1.7	−1.7	0.2	5.8	7.9	14.0
Angular size	6.3"	9.2"	24.3"	35.4"	20.2"	17.1"	30.9"	18.8"	3.6"	2.3"	0.1"
Illumination	68%	12%	51%	33%	100%	97%	100%	100%	100%	100%	100%
Distance (AU) from Earth	1.067	0.729	0.688	0.472	0.464	0.548	6.375	8.851	19.809	30.177	31.873
Distance (AU) from Sun	0.423	0.310	0.727	0.723	1.453	1.490	5.445	9.099	20.073	30.059	31.032
Right ascension (2000.0)	15h56.3m	15h37.8m	17h40.1m	19h34.9m	2h59.8m	2h25.0m	14h09.3m	8h55.1m	22h35.2m	21h09.4m	17h31.6m
Declination (2000.0)	−23°12'	−17°10'	−26°55'	−24°43'	16°10'	15°07'	−11°57'	17°55'	−9°45'	−16°32'	−15°42'

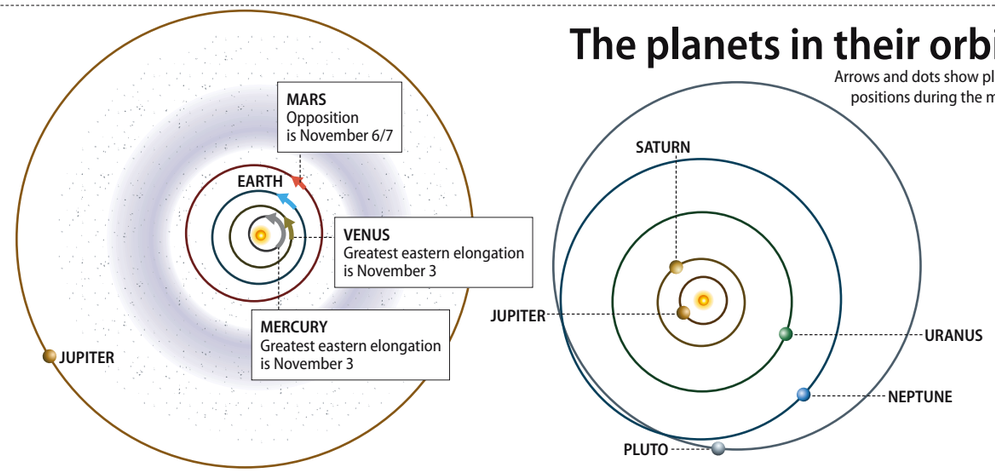
Jupiter's moons

Dots display positions of Galilean satellites at 6 A.M. EST on date shown. South is at top to match the view through a telescope.


01 JUPITER EUROPA GANYMEDE IO CALLISTO 10
11 IO CALLISTO GANYMEDE EUROPA JUPITER 20
21 IO CALLISTO GANYMEDE JUPITER EUROPA 30

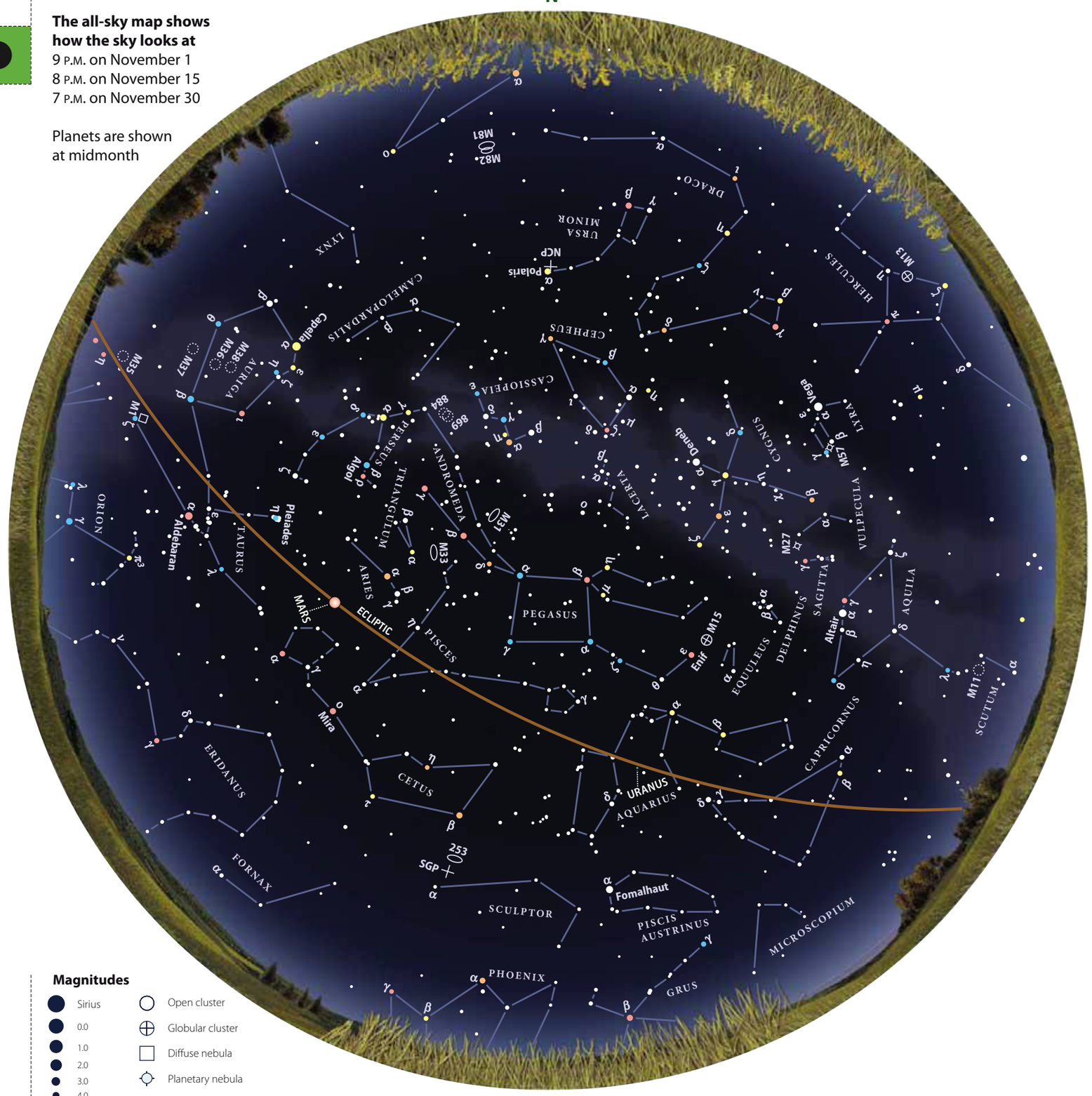
The planets in their orbits

Arrows and dots show planets' positions during the month.



The all-sky map shows how the sky looks at
9 P.M. on November 1
8 P.M. on November 15
7 P.M. on November 30

Planets are shown at midmonth



Magnitudes

Sirius	Open cluster
0.0	Globular cluster
1.0	Diffuse nebula
2.0	Planetary nebula
3.0	Galaxy
4.0	
5.0	

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

november 05

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
		[01]	[02]	[03]	[04]	[05]
[06]	[07]	[08]	[09]	[10]	[11]	[12]
[13]	[14]	[15]	[16]	[17]	[18]	[19]
[20]	[21]	[22]	[23]	[24]	[25]	[26]
[27]	[28]	[29]	[30]			

01 New Moon is at 8:25 P.M. EST

03 Mercury is at greatest eastern elongation (24°), 11 A.M. EST

Venus is at greatest eastern elongation (47°), 2 P.M. EST

The Moon passes 1.3° south of Mercury, 6 P.M. EST

04 The Moon passes 0.2° north of Antares, 2 A.M. EST

Asteroid Fortuna is at opposition, 7 A.M. EST

05 The Moon passes 1.4° south of Venus, 2 P.M. EST

07 Mars is at opposition, 3 A.M. EST

08 The Moon passes 5° south of Neptune, 3 P.M. EST

First Quarter Moon is at 8:57 P.M. EST

09 Mercury passes 1.9° north of Antares, 11 A.M. EST

The Moon is at perigee (229,914 miles from Earth), 7:23 P.M. EST

10 The Moon passes 3° south of Uranus, 5 A.M. EST

15 The Moon passes 3° north of Mars, 1 A.M. EST

Full Moon is at 7:57 P.M. EST

17 Leonid meteor shower peaks

Asteroid Pallas is in conjunction with the Sun, 9 P.M. EST

18 Mercury passes 3° north of Antares, 11 A.M. EST

21 The Moon passes 4° north of Saturn, 10 P.M. EST

22 Saturn is stationary, 1 P.M. EST

23 The Moon is at apogee (251,264 miles from Earth), 1:17 A.M. EST

Last Quarter Moon is at 5:11 P.M. EST

24 Mercury is in inferior conjunction, 11 A.M. EST

27 The Moon passes 1.1° north of Spica, 11 P.M. EST

29 The Moon passes 3° south of Jupiter, 3 A.M. EST

ONLINE EXTRA For definitions of terms, visit www.astronomy.com/glossary

THE DEEP SKY

Dark skies may be best for deep-sky observing, but plenty of great targets are visible from typical suburban backyards.

Double your pleasure

Andromeda, the fair princess of the sky, is a constellation rich in interesting sights. Although we won't cover the great Andromeda Galaxy (M31) and its two satellite companions (M32 and NGC 205) in detail this month, you should take time to visit them. Instead, we'll follow some lesser-known trails suitable for suburban observers.

The first stop for small-scope owners is at the trail head, the fabulous double star Gamma (γ) Andromedae on the eastern end of the constellation's southern string of bright stars. The luminary of the pair has a brilliant topaz color, on the orange side of yellow. The pale blue companion lies 10" away, so you'll need a medium-power eyepiece to put some space between them.

Next, hop over to Beta (β) And, the middle of the three bright southern stars. Your target is the modestly bright compact galaxy NGC 404, located just north of Beta.

Because the galaxy hides in the bright yellow star's glare, and you don't want to blast the faint-light detectors in your retina, don't look at Beta with your observing eye. Instead, go to medium power (100x or so) and shift north so the star lies just out of the field of view; then use your observing eye. Observers have mistaken the 10th-magnitude fuzzball for both a comet and an internal reflection of the star.

Blowing its top

Through a small telescope, you can catch a glimpse of a star not long for this universe. Every couple of weeks, RX Andromedae jumps from invisibility up to 10th magnitude.

It's pretty cool to suddenly see a star through your eyepiece that wasn't there the night before. Cataclysmic variable stars like RX And are actually close binary systems locked in a deadly dance.

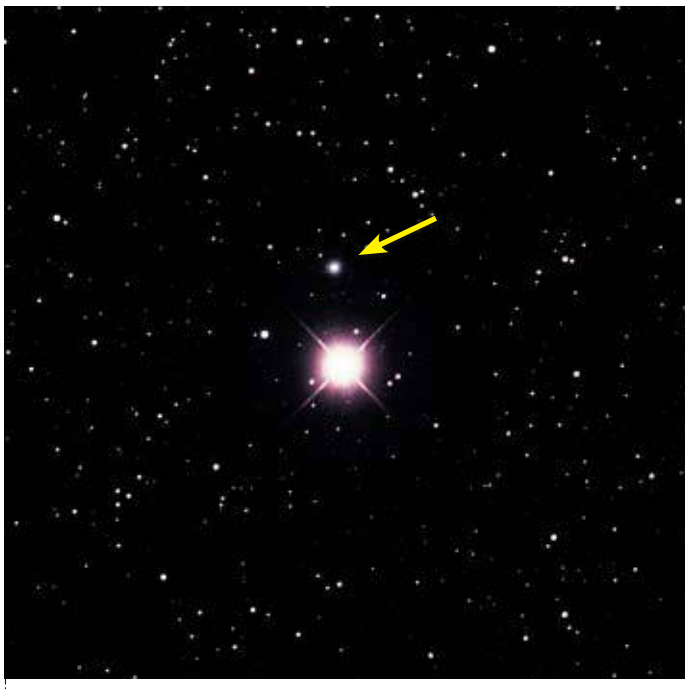
A small but massive star is sucking the life out of a bloated companion. As gas flows from the companion toward the central star, it piles up in a flat accretion disk. When enough gas accumulates, a runaway thermonuclear reaction begins, vaulting the system's brightness by four magnitudes until the excess burns off.

No one knows exactly when the next blast will be, so it pays to check in on the system from time to time. Find detailed charts from the American Association of Variable Star Observers at aavso.org. Type in "RX And" and print out the b, c, and d charts.

Each chart has a set of numbers on it: the magnitudes of comparison stars with their decimal points omitted, to avoid confusion with stars. Before you know it, you'll be estimating the target's brightness relative to comparison stars to within 0.3 magnitude.

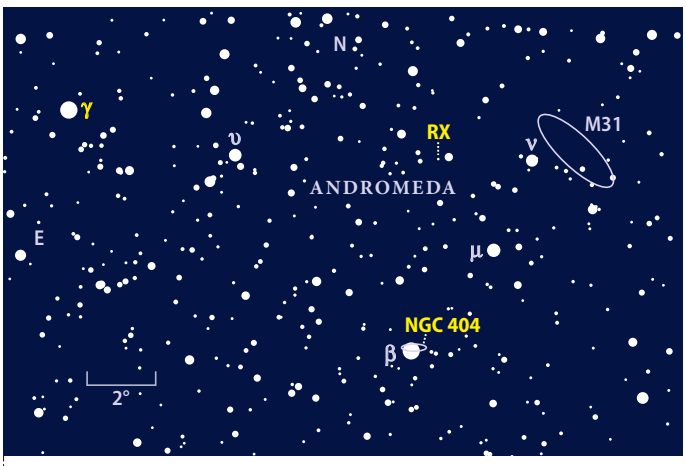
You may be surprised that after four or five attempts, you can do it from memory. Click on "plot a light curve" on the AAVSO web site to view RX And's recent stellar tantrums.

While you're in the area, hunt down asteroid 89 Julia. This 9.5-magnitude space rock can be tracked from suburban sites with a 6-inch scope.



JOE LIDDELL

THE FUZZY BLOB of lenticular galaxy NGC 404 (arrow) barely shines through the glare from magnitude 2 Beta Andromedae.



ASTRONOMY: ROEN KELLY

MERCURY AND VENUS reach greatest eastern elongation within 3 hours of each other November 3, putting them on display in evening twilight.

THE PLANETS

Mars mania returns as the planet reaches the peak of its impressive 2005 apparition, but don't let good views of Venus and Saturn pass you by.

Mars reaches opposition and best visibility in early November — the first time since August 2003. It's one of two brilliant planets occupying the early evening sky. Venus appears brighter, setting in the southwest after sunset while Mars rises in the east.

Although Mars rightly should be the center of attention, don't forget the two distant gas giants, Uranus and Neptune. Both of these planets are easy to see with binoculars as soon as darkness falls.

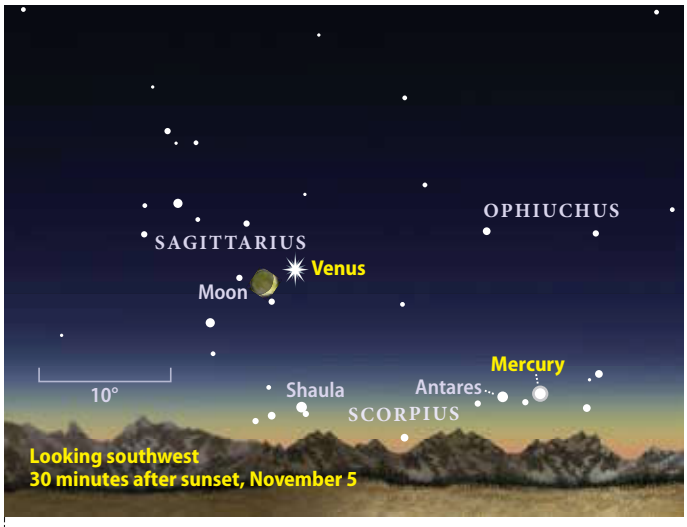
The late-night appearance of Saturn rounds out the month's planetary viewing. It's at its best before dawn. However, this month's tour begins, as usual, in the evening twilight sky.

Venus dazzles the senses with its brilliance. You can find it in the southwest as soon as darkness falls and follow it until it sets, around 8 P.M. local time.

Venus reaches greatest elongation November 3, when it lies 47° east of the Sun. Unfortunately, this wide separation doesn't translate into much altitude during this autumn's evening apparition.

Venus traverses Sagittarius this month and passes less than 3° south of the Lagoon Nebula (M8) on the 5th. The nebula's low altitude once the sky grows dark will make it a challenge to see, however. A clear southwestern horizon and good sky transparency are required for a nice view of this alignment.

A slender crescent Moon lies just 3.5° left of Venus that same evening. Five days later, on November 10, Venus passes 2° south of the 8.5-magnitude globular cluster M22, and, on the 13th, 3° south of the even brighter globular M28. As Venus crosses to the eastern side of Sagittarius, it passes within 0.5° of Nunki (Sigma [σ] Sagittarii) November 17 and 18.



ASTRONOMY: ROEN KELLY

MERCURY AND VENUS reach greatest eastern elongation within 3 hours of each other November 3, putting them on display in the evening twilight.

The time around greatest elongation provides the best views of Venus. Any telescope will let you follow the planet's changing phase and diameter.

Venus begins November 50-percent lit, appearing like a tiny First Quarter Moon. By the end of the month, its phase wanes to 33-percent illumination. The planet's orbit carries Venus closer to Earth this month, and as a result, its apparent diameter increases from 25" to 36".

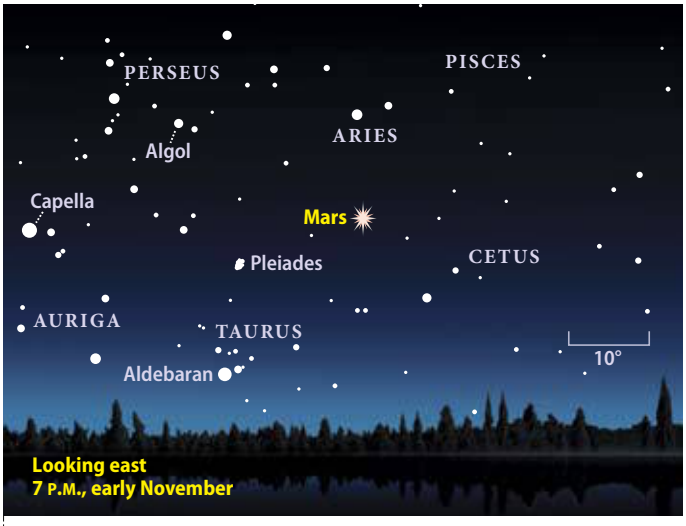
Mercury also reaches greatest eastern elongation this month, but it suffers from the same poor geometry afflicting Venus. It never reaches a high enough altitude above the southwestern horizon to be seen easily.

Mercury's greatest elongation comes just 3 hours before Venus'. Nearly simultaneous elongations, within 12 hours of each other, are rare — the two inner planets don't accomplish the feat again until 2134.

Probably the best time to search for fleeting Mercury comes November 9, when it lies 2° north of the 1st-magnitude star Antares in Scorpius. Then, Mercury lies 4° above the horizon 30 minutes after sunset. The planet shines at magnitude –0.1, a full magnitude brighter than the star.

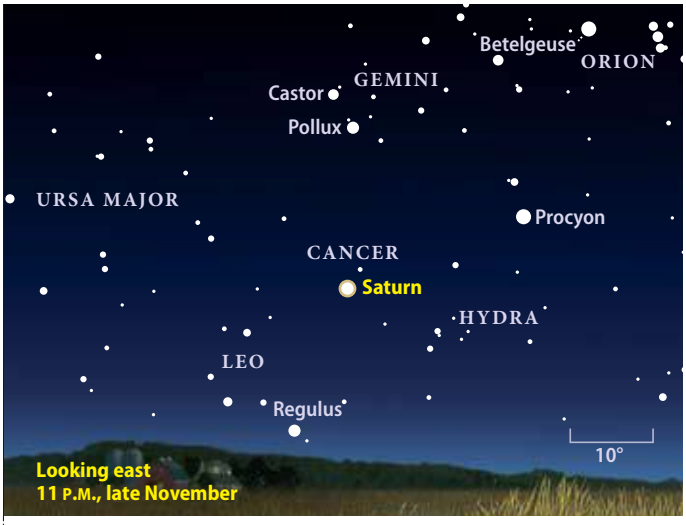
Moving east of Sagittarius brings us to a region of sky devoid of bright stars that's low in the south as darkness falls. This is the constellation Capricornus the Sea Goat, the current home of **Neptune**.

Of course, the planet lies a few light-hours from Earth, while the stars reside tens and hundreds of light-years beyond.



ASTRONOMY: ROEN KELLY

MARS PEAKS AT OPPOSITION November 7, when it shines brilliantly at magnitude –2.3 and remains visible all night.



ASTRONOMY: ROEN KELLY

SATURN RETURNS TO PROMINENCE in November, rising around midnight and appearing high in the south by daybreak.

Still, the stars of Capricornus serve as useful guides for finding the planet, which glows dimly at magnitude 7.9.

Begin by locating Theta (θ) Capricorni. Neptune lies in the same binocular field of view as this star. On November 1, Neptune lies 0.1° north of a 7th-magnitude star. For the rest of the month, you can follow the planet's northeastern motion relative to this star through binoculars or a small telescope.

One constellation farther east, within the boundaries of Aquarius the Water-bearer, lies **Uranus**. This easy binocular object glows at magnitude 5.8 and appears higher in the sky than Neptune, both of which make it far easier to see. Uranus appears as the brightest "star" between Lambda (λ) and Sigma (σ) Aquarii, in the eastern part of the constellation below the familiar "Water Jar" asterism.

Mars lies low in the east after sunset and climbs high in the south by local midnight. It reaches opposition November 7, when it peaks in brightness at magnitude –2.3. The Red Planet easily outshines every other point of light in the sky after Venus sets. It lies about 15° west of the Pleiades star cluster (M45), among the background stars of Aries the Ram.

Although opposition usually marks a planet's closest approach to Earth, Mars was a little closer at the end of October. The discrepancy arises because Mars' orbit is elliptical, and the planet is currently moving away from the Sun.

This year, Mars lies 43 million miles from Earth at opposition, about 9 million miles farther away than during the great 2003 apparition. Yet Northern Hemisphere observers should get views rivaling those of 2003 because Mars lies 30° higher in the sky.

Details on the planet's surface appear sharpest when viewed through the least amount of Earth's atmosphere. This means the best telescopic views will come around local midnight. And a bigger disk also provides a better image.

Mars' apparent diameter shrinks from 20" to 17" during the course of November. For complete details on observing Mars, see "Set your sights on Mars" on page 76.

By the time Mars stands high in the south, **Saturn** rises in the east. On November 30, Saturn appears well clear of the horizon by midnight. It shines at magnitude 0.3 and will continue to brighten through the end of the year. Your best telescopic views will come in the early morning sky.

Saturn lies among the background stars of Cancer the Crab, not far southeast of the bright Beehive star cluster (M44). On November 25, the Last Quarter Moon passes 4° northeast of Saturn.

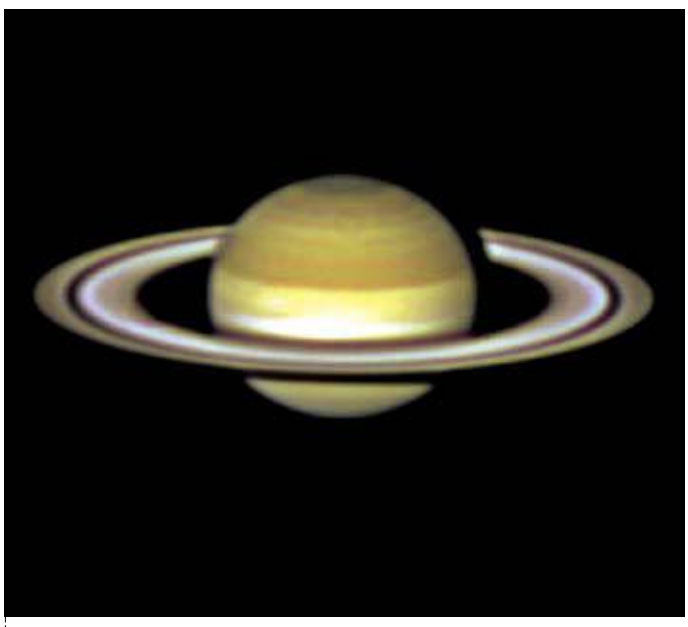
The rings, always a wondrous sight through small telescopes, remain on fine view. However, they no longer hide the planet's north pole, as they did until 2003.

From our point of view, we see the rings closing as Saturn moves along its orbit. By 2009, they'll ap□ ear edge-on, essen tia□ ly disappearing from view.

Several of Saturn's moons can be spotted through the eyepiece of a 4-inch or larger telescope. Titan glows brightest, at mmgnitude 8.3, appearing like a bright star in the sfme field of view as the planet. The moon lies due north of the ringed planet November 15 and due south November 7 and 23.

Jupiter returns to view in the morning sky by the second week of November and grows more conspicuous as the month progresses. Shining brightly at magnitude –1.9, you won't mistake it for any other object in the eastern sky. The telescopic view of the giant pl net will improve markedly as it climbs higher in the coming months.

Of min□ note)he Sun ters the constellatior Opdiu .hus thedSerpent-bearer N□ v-ember 29 and remains there through the first 2 weeks of December. This m□ rks the S□ 's only foray from the 12 familiar constellations ofOthe zodiac during the course of the year.



SUBARU/NAOJ

SATURN'S EXQUISITE RINGS, with details including the dark Cassini Division dividing the A and B rings (the A ring sits outside the Cassini Division), set off the planet's delicate yellow glow.

METEORS AND MOONS

The month's major meteor shower may fizzle through interference from the Full Moon, but a normally minor shower could put on an excellent show.

A torrid shower?

Bright fireballs just might herald this year's appearance of the Taurid meteor shower. Meteor researcher David Asher of Armagh Observatory in Northern Ireland predicts the potential for "swarm" rates this year in late October and early November. New Moon arrives November 2, so it couldn't be timed better for the possible peak. (The shower's normal peak occurs November 12.)

The radiant comes in two parts, with a northern and southern component. Because Earth moves around the Sun, meteor radiants drift each day.

Over the period the Taurids are active, both radiants first appear in Pisces, drift across Aries (near Mars), and move into Taurus in early November. The radiants remain visible most of the night.

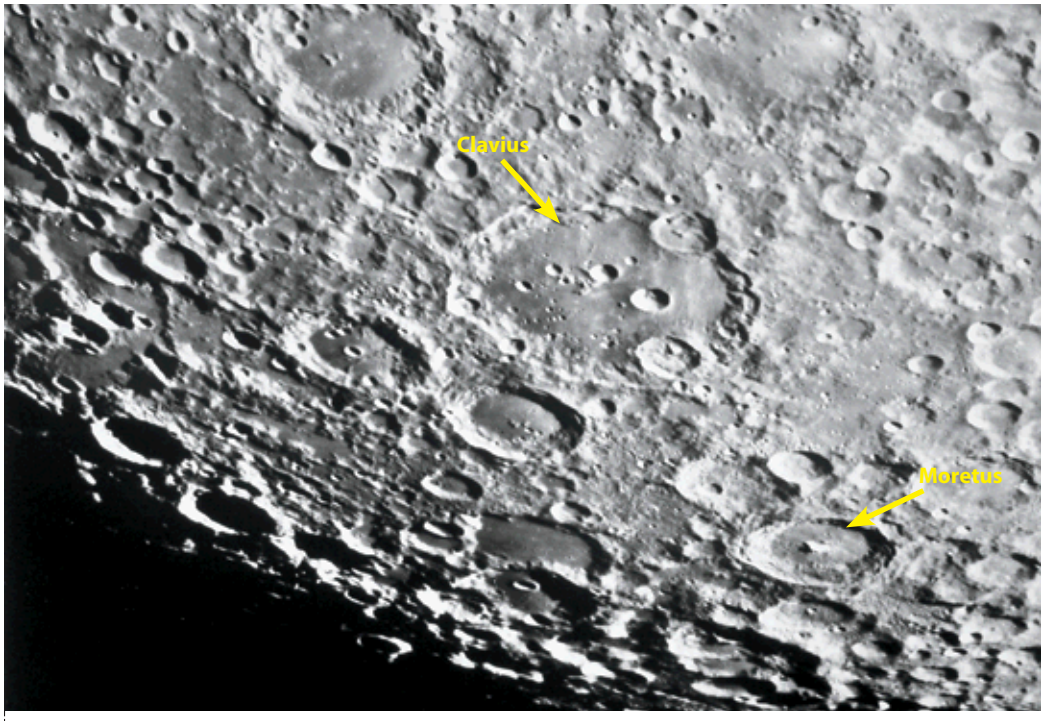
November's normal meteor highlight, the Leonid shower, suffers this year from interference with the Full Moon. Rates for the Leonids have declined significantly from the storm levels a few years ago, so you may see only 5 to 10 meteors per hour at the peak November 17. If you still want to observe the shower, face away from the Moon and try to block its light with buildings or trees.

Moon feature: Moretus

The crater Moretus lies southeast of the giant crater Clavius in the Moon's mountainous southern highlands. Moretus spans 71 miles and showcases one of the highest central peaks of any crater (more than 1.6 miles high) and high terraced walls that reach 13,000 feet above the crater floor.

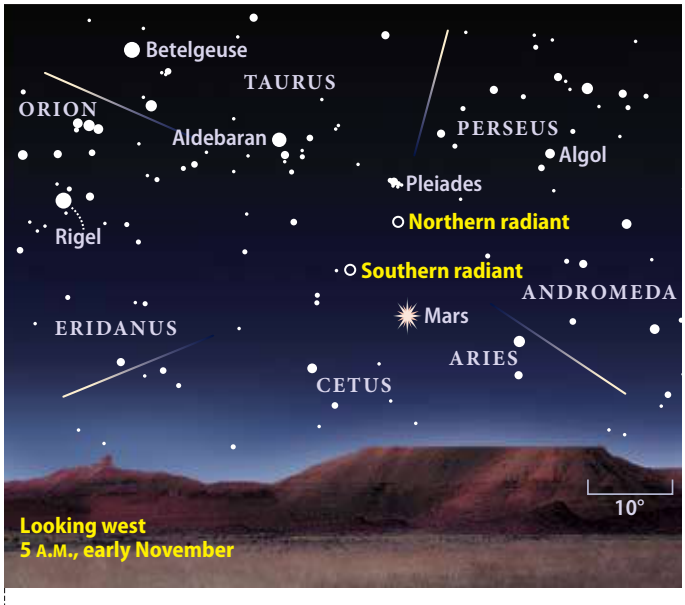
The Moon's libration affects the appearance of Moretus. Libration is the gentle nodding back and forth of the lunar limb, caused in part by the Moon's tilted orbit.

A favorable libration can give Earth-based observers a better view of the polar regions. The southern limb tilts in our direction following the November 15 Full Moon, allowing a better view of Moretus' floor. A good time to look is between November 22 and 24, as the Sun sets over the region.



FROM *CONSOLIDATED LUNAR ATLAS* (LPL/UA)

LUNAR CRATER MORETUS calls the southern highlands home. Look for it near the limb, south and a little east of giant Clavius.



ASTRONOMY: ROEN KELLY

THE TAURID METEOR SHOWER may put on an impressive display in early November, if optimistic predictions hold true.

COMETS AND ASTEROIDS

Ironically, some deep-sky objects are easier to see than solar system objects. Use Mars to track down an asteroid 10 times the size of the planet's small moon, Phobos.

A comet gets the goat

Glowing modestly at 10th magnitude, Comet C/2005 E2 (McNaught) lies in Capricornus and appears low in the south during the evening hours. To get a decent look at it, yoa will need to head away fromX the light-polluted city anm out tP ard dark, moohlX ss skies.

is mean planning an observing trip either at the beginning of November or in the last 2X weeks

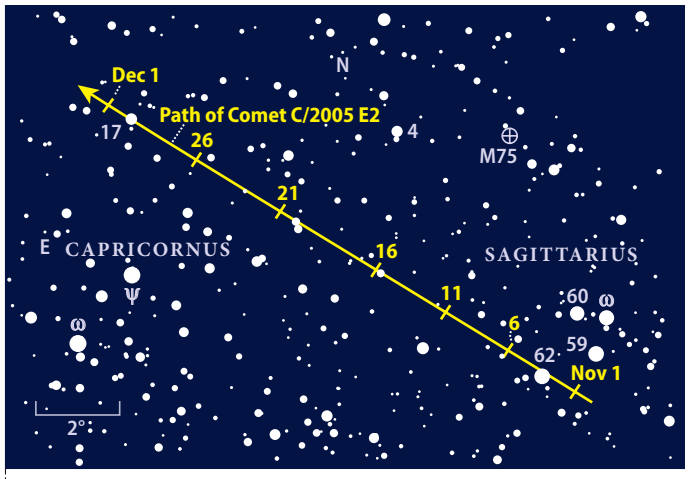
RememX er that a key reasLn to chase#conets is not simplo tX add to a lifetime list, but to sharpen your observing skills in preparation folX o e that will display all sorts of detail. It's always a good idea to limber up and stretch before an activity, and observing is no different. The longer you've been away from the eyepiece, the more important it is to start easy.

Aim your scope at the nearby globular star clusters M55 and M75 in neighboring Sagittarius. Through any telescope, M55 will be a large, brighX object with stars 'pilling across its fece.

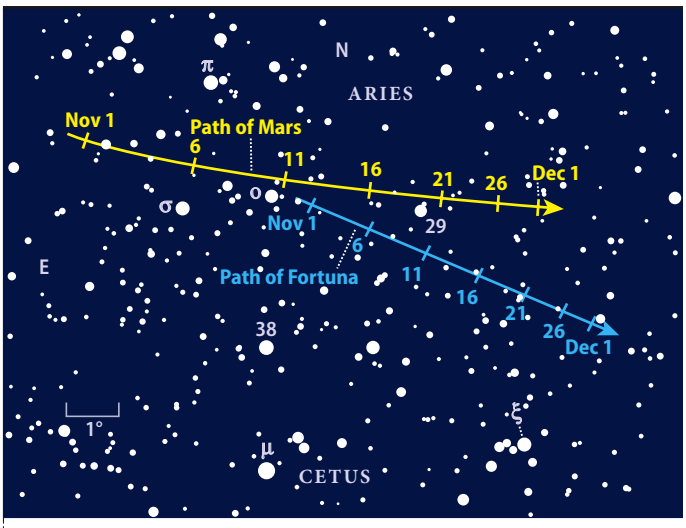
M75, a few degrees to the north, provides a good opportunity to compare the shX pe and stX ecture with Comet McNaught. The globular appears just one magnitude brighter than the comet.

M75's brightest stars glow at X agnitude 14.5, so scopes less than 12 inches in aperture will o be able to resolve it into its conX eituent stars. Instead, look at its oX erall shape, the definition at the edges, and the centX al con ensation.

Some comets and globulars have bright, pinpoint regions marking their centers, while others gradually get brighter.



COMET C/2005 E2 (McNAUGHT) should glow at 10th magnitude this month as it cuts through Capricornus the Sea Goat.



ASTEROID 19 FORTUNA parallels the path of brilliant Mars in November, providing a handy guide for locating the 9th-magnitude rock.

Their edges appear different, eowever. A globular is diffuse all t"e way around, but a comet has one well-dX fined zone. This s the bow shock, where the solar sind pushes bX k cometary dust a bit like the way a boat's bow makes a!qave.

A lucky break

Thanks to a fortunate coincidence, asteroid 19 Fortuna X racks alongside Mars throughout November. In reality, Fortuna lies beyondX Mars, as you'd expect for a typical main-belt asteroid. Not ce how the aster ovd'n daily motion is slower than the planet's, betraying its greater distance.

Although Fortu a neverX es moo than 4°X frol sX teakenge to see. A montX , placing it easily within the same field of view through most binoculars, you'll need to use Omicron (o) and 29 Arietis as starting points for a telescnpic hunt. BecauX e sX veral stars on the findem chart atX left havo a brightness similar to 9th-magnitude Fortuna, use the tr ed-and-true methX d tf pøsitive identification: Make a quick sketch of the star field on one night, then return a nX ht or two lat r to see which onX moveX . Fortuna takes about 2 nights to shift the apparent width of the Full Moon.

One of the top astronomers of the day, J. R. Hind, discovered Fortuna August 22, 1852. The first asteroids found are among the biggeX s, and at 150 miles across, Fortuna ronks among the top 10. By comparison, Mars' biggest moon, Phobos, measures a mere 14 miles across — no wonder it's a challenge to see.

Martin Ratcliffe *is former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist for Environment Canada.*

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Move over, Pluto. Even larger ice worlds exist in the outer solar system.

/// BY FRANCIS REDDY

The tenth planet

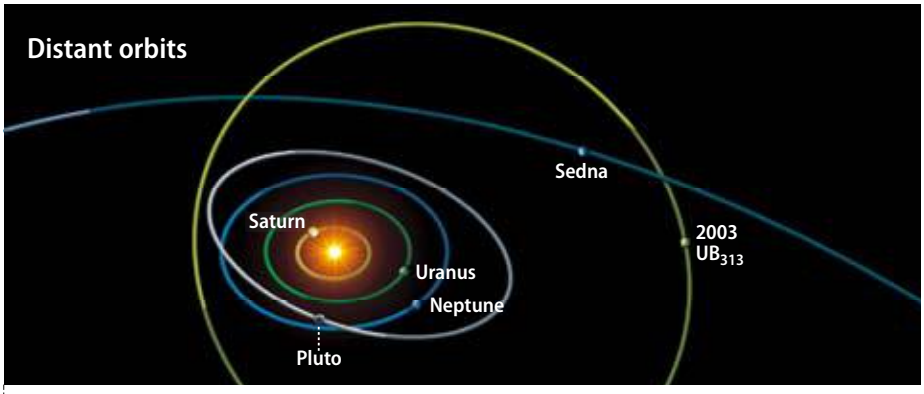
"Get out your pens. Start rewriting the textbooks," said Caltech astronomer Michael Brown in a hastily arranged teleconference late July 29. His team had discovered a new object — temporarily named 2003 UB_{313} — that is, he says, not only the farthest directly observed body in the solar system and the fourth brightest Kuiper Belt object. It is also our solar system's tenth planet.

Since beginning a 5-year, all-sky survey with Palomar Observatory's 48-inch Samuel Oschin Telescope in 2001, Brown and his colleagues Chad Trujillo at the Gemini Observatory on Mauna Kea, Hawaii, and David Rabinowitz at Yale University have found several objects about three-quarters Pluto's size. These include Quaoar, Orcus, and Sedna. The astronomers first imaged 2003 UB_{313} October 21, 2003 — but the ice world moved so slowly along its orbit it eluded software designed to look for moving targets until the scientists reanalyzed their images January 5, 2005.

"I think it's cool," says Alan Stern, an astronomer at the Southwest Research Institute in Boulder, Colorado. He's also the principal investigator on NASA's New Horizons mission to Pluto, set to launch next year. "I don't think it's surprising."

Pluto orbits the Sun with hundreds of other objects in the Kuiper Belt, a region between 30 and 50 AU from the Sun. (One AU, or astronomical unit, equals the average Earth-Sun distance.) For more than a decade, many planetary scientists — Brown and Stern among them — suspected bodies larger than Pluto lurked in the outer solar system's frigid darkness.

The new object now lies 97 AU from the Sun — more than 9 billion miles (14.5 billion kilometers) away, or 3 times Pluto's distance — and has reached the farthest part of its 557-year orbit. In 280 years, a little longer than Pluto takes to orbit once, 2003 UB_{313} will reach its closest point to the Sun at a distance of 38 AU.



ASTRONOMY: ROEN KELLY

THE TENTH PLANET is now slightly more distant than Sedna, which the same team discovered last year. But 2003 UB_{313} now lies near its farthest point from the Sun, while Sedna will cruise out to 10 times its present distance. The new world's orbit tips a remarkable 44° out of the ecliptic plane — much more so than either Sedna (11.9°) or Pluto (17.2°).

Brown's team has proposed a permanent name to the International Astronomical Union (IAU), the organization that approves solar-system nomenclature. He won't disclose the name pending acceptance, which could take a while. On August 4, the IAU announced 2003 UB_{313} won't be named until efforts to define a planet's minimum size — in progress since 1999 — reaches a conclusion. Only then will astronomers be able to classify the body.

Plus-size Pluto

"It's definitely bigger than Pluto," says Brown. Astronomers don't know if the new object is bright because its surface is especially shiny, or if it's bright because it's big. But even if 2003 UB_{313} has a surface that gleams like fresh snow on Earth, reflecting 90 percent of incident sunlight, the icy world can only be as bright as it is if it's slightly larger than Pluto, or more than 1,413 miles (2,275 km) across.

Brown says his team's first attempt to detect 2003 UB_{313} with the Spitzer Space Telescope failed due to a technical glitch that pointed the telescope in the wrong place. Another attempt with Spitzer, and planned observations with the 30-meter IRAM Telescope in Spain and the Hubble Space Telescope, should help the scientists determine its maximum size.

On January 25, using the Gemini North Telescope on Mauna Kea, Hawaii, Chad Trujillo studied the object's near-infrared spectrum, which provides information about surface properties. Preliminary results indicate a surface remarkably similar to Pluto's, covered in frozen methane.

"Only one other object in the Kuiper Belt has a surface that looks like that," Brown says. The object, designated 2005

Francis Reddy *is an associate editor of* Astronomy.

FRANCIS REDDY

A WHOLE NEW WORLD — temporarily dubbed 2003 UB_{313} — lurks in the outer solar system's frigid reaches. This illustration shows what the tenth planet might look like up close. It bears a striking similarity to Pluto, but it is larger, farther away, and nearly gray.

/// AT A GLANCE

2003 UB_{313}

Discovered: October 21, 2003, by Michael E. Brown, Chad Trujillo, and David L. Rabinowitz

Name: Proposed, but on hold until planetary status is decided

Constellation: Cetus

Position: R.A. 01h37m06s, Dec. –5°36'12" (Nov. 1, 2005)

Magnitude: 18.8

Current distance from Sun: 96.9 AU (1 AU is the Earth-Sun distance.)

Light travel time: 13.3 hours, one-way

Surface temperature: –405° F (–243° C)

Surface composition: Methane ice (Pluto-like)

Orbital period: 557 years

Orbital inclination: 44.2°

Closest point to Sun: 37.8 AU

Farthest point from Sun: 97.6 AU

FY_9 and also announced at the team's July teleconference, is the brightest Kuiper Belt body after Pluto. About three-quarters Pluto's size, 2005 FY_9 also appears to be coated with methane.

"If 2003 UB_{313} ever got close to the Sun, all the methane ice would have boiled off immediately," explains Trujillo. This means the planet probably hasn't been heated significantly since the solar system formed 4.5 billion years ago.

One notable difference between the new object and Pluto, they say, is that while Pluto is somewhat red, 2003 UB_{313} is almost gray. For the moment, they can't explain why two otherwise similar objects have such markedly different colors.

But is it a planet?

No one disputes the new object's size makes it the largest solar system object discovered since Neptune was found in 1846. But Brown's crowning of 2003 UB_{313} as a tenth planet has rankled some astronomers and reinvigorated the simmering debate over how to define a planet — and if any scientifically useful definition can include Pluto.

"It's a great discovery," says Alan Boss, a planet-formation theorist at the Carnegie Institution of Washington. He wouldn't refer to any of these distant ice worlds as planets without some sort of qualifier. "Call them Kuiper Belt planets, if you want."

During the past few years, many researchers — including Brown — have argued that Pluto itself should be demoted. But, he now reasons, if we're comfortable conferring planetary status on Pluto, it's inconsistent to deny the title to even larger bodies. Brown says the word "planet" is a cultural term, not a scientific one, and culture has embraced Pluto as a planet.

Iwan Williams, president of the IAU's Planetary Systems Sciences Division, thinks along similar lines, but comes to a different conclusion. "The problem is that we are trying to invent a scientific definition for something that is in essence cultural, or social, or even astrological."

Planets, as a collective term, were important in the early days of astronomy, but now, scientists see greater importance in groups of objects that have a common formation process or interesting dynamics. Defining "planet" in a way that roughly matches the existing nine planets doesn't make scientific sense.

"For historical and cultural reasons, we should define a set of bodies called 'historic planets,' which are the nine planets," he says.

Alan Stern is more generous: "I think [asteroid] Ceres should be considered a planet. I think anything big enough to make itself round due to gravity should be considered a planet."

Stern says we should get used to the idea our solar system has dozens of planets. "The floodgates are open now, and in 10 years we'll have a whole bunch of these little guys." He calls them dwarf planets.

Eight is enough

"Stern's view has a lot of merit because there's a physical principle involved," says Brian Marsden of the Minor Planet Center in Cambridge, Massachusetts. "They could be called dwarf planets, but where do you draw the line?" Asteroids and Kuiper Belt objects are already considered minor planets, and a dwarf-planet class does nothing to eliminate the "fuzzy boundary" between these objects and the eight major planets everyone agrees on.

"We should use this opportunity to put Pluto in its place" as a minor planet, Marsden says. "Quite frankly, I feel that if we call this [2003 UB_{313}] a tenth planet, we're in for a lot of trouble in the future."

For Alan Boss, only the most dynamically important bodies merit planetary status, which excludes Pluto. "We're learning something very basic about our solar system," he says. "The fact that we may need to go back and change the textbooks shouldn't be thought of as something bad. It should be thought of as scientific progress." A

Sharpen your observing eye by capturing what you see on paper.

/// BY MICHAEL E. BAKICH

Sketch the universe

Say you love observing, but you're not

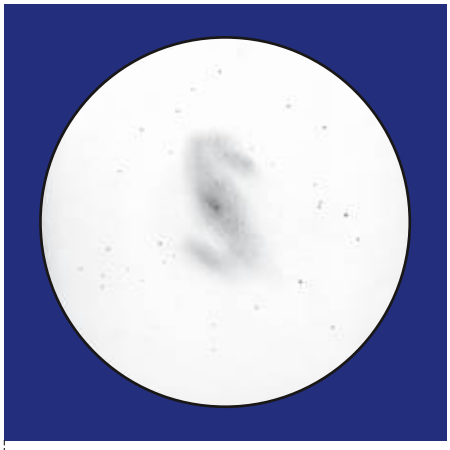
ready to make the commitment to capturing objects with a digital camera. There's an alternative that will allow you to keep your treasured memories of planets, stars, and galaxies: sketching. Drawing with pencil and paper lets you make a pictorial record of your observations and become a better observer in the process. Sketching is also fun, and you'll be amazed at the improvement in your ability to see faint details in objects over time.

Not Da Vinci or Raphael?

When I talk to observers about sketching, there's one point I can't make strongly enough: You don't have to be an artist to do it. Be happy with how you sketch, and know — with absolute conviction — that your results will get better.

As a first step, learn to draw a circle. Much of what you sketch will be circular (whole solar disks and planets), and all of the non-circular objects will be located in the circular field of view of your telescope's eyepiece. You can draw your circles either with a compass or computer software. The advantage of the latter is the ability to print quickly as many circles as you need.

Don't make your circles too large. The first few times I sketched, I used circles that barely fit on a page. The sketches took too long to make. After a few of these marathon sessions, I settled on a circle 4 inches (10 centimeters) in diameter. Because I was just starting to sketch, I didn't feel confident using smaller circles. Drawing tiny details requires a fine touch I didn't then possess. Pre-drawn observing forms showing different planetary orientations are available from both the British Astronomical Association (www.ast.cam.ac.uk/~baa) and the Association of Lunar and Planetary Observers (www.lpl.arizona.edu/alpo).



DAVID J. EICHER

SPIRAL GALAXY M81 in Ursa Major makes a good target for sketchers because it's one of the brightest galaxies in the sky. Through a 17.5-inch f/4.5 Newtonian reflector equipped with a Tele Vue 32mm Plössl eyepiece (63x), the galaxy's spiral arms appeared clearly.

Training your eye

When you start sketching, you will, by necessity, spend more time looking at objects rather than moving quickly from one object to another. To make a sketch, you must memorize small areas of detail before transferring what you're seeing to paper. The more objects you sketch, the more detail you'll notice as part of your normal observing routine — things you were unaware of before. In essence, your eyes (or eye, because most observers use one eye exclusively) are being trained.

To appreciate this training of your eye, pick a celestial object. It doesn't matter if it's a planet or a galaxy. The only requirement is that you can see it well through your telescope and can make a few observations of it over a month's time. Observe and sketch the object once a week for 4 weeks. Use the same telescope and eyepiece, and observe from the same site. Take 15 or 20 minutes each session to sketch the object. When you're done, you'll have four sketches to compare. You will see your improvement.

We've all observed objects and wished we had a larger telescope. Sketching helps you see the maximum detail possible through your current equipment.

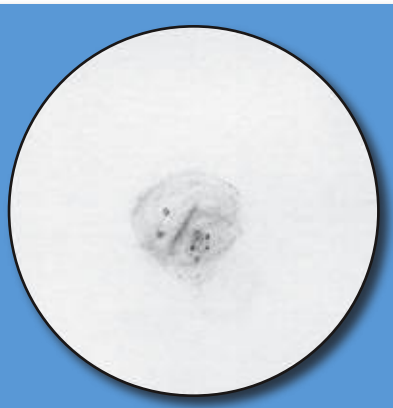
Preparation and materials

In addition to your sketching forms, you'll need a red flashlight — preferably a dimmable one — for faint objects, and a white light when you're sketching the Moon. Faint red light degrades your dark adaption less than any other color.

Because it's so bright, the Moon requires a different approach. You *want* to ruin your dark adaption to sketch it. Sit near a white light bright enough to trigger your daytime (photopic) vision, which is better for seeing both detail and color than your night (scotopic) vision. A single incandescent bulb from a yard or porch light usually emits enough light to do this. I recommend this technique for solo observing only. In other words, don't shine a bright white light near observers at a star party.

Ideally, set up a short table in a comfortable position near the eyepiece. If this is impractical, you'll need a clipboard or some sort of sturdy notebook to back up your paper. Holding a red flashlight — with your hand or teeth — for any length of time is tiring. If you can fasten the light to your

Michael E. Bakich *is an associate editor of* Astronomy.

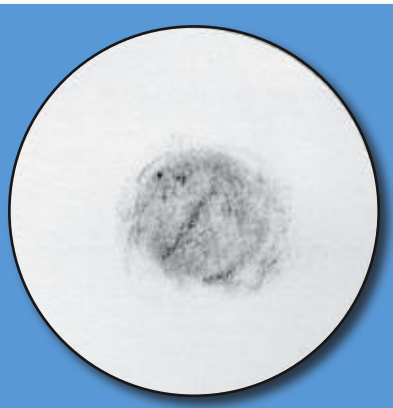


2-inch f/12 at 50x

2.8-inch f/6.8 at 23x

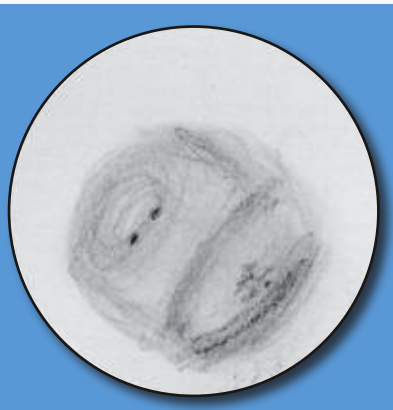
3.2-inch f/9 at 32x

3.4-inch f/7 at 15x



3.6-inch f/10 at 53x

3.6-inch f/5.6 at 56x



4-inch f/8.6 at 28x

4.2-inch f/6 at 105x

5.2-inch f/8 at 69x

7.2-inch f/9 at 52x

sketching board or suspend the light above it, you'll be more relaxed at the eyepiece.

If possible, sit while sketching. When you're observing, comfort is important, especially when you're looking for minute details and transferring them to paper.

Get the graphite out

Start inside with your sketch pad, board, a common #2 pencil, and a good quality soft eraser. Practice making darker and lighter strokes by exerting more or less pressure. Also practice filling in areas. (More advanced sketchers will benefit from an Eberhard Faber Ebony art pencil, which will produce better results than a #2.)

When you're ready to head outdoors, get some lighter- and darker-shade pencils. At least a dozen different sha es exist for com mon art pencils. Any art supply store will have all you'll need. Also, buy a pencil sharpener and a high-quality eraser — don't hesitate to use them.

The paper you choose is important. Unless you live in a dry climate, choose a relatively thick paper or perhaps even a thin cardboard. All paper absorbs airborne moisture, but thin paper has a greater tendency to curl.

Smudging

Some observers iike to use p-ncils with soft lead when they' e sketc inA ctmets, nebu lae, and galaxies. To simulate the glow of nebulosity, first draw the outline of the object. Gently use a clean finger to smudge the outline into a blob that represents the object accurately.

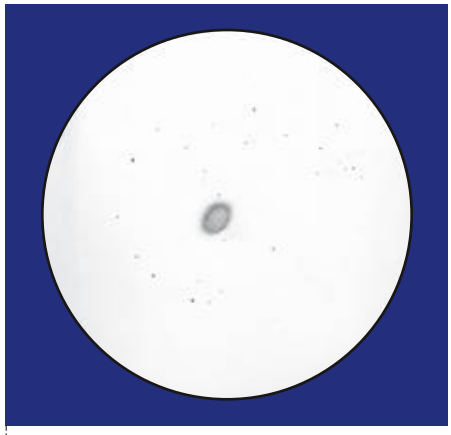
For smudging a celestial object's image, coarse-grade sketching paper works best. An art supply store will provide some recommendations for paper and pencils when you tell them what you plan to do.

At the telescope

Begin by drawing what you see. Notice details, but don't dwell on them. Let your mind capture the whole object. If you've chosen the Sun, the Moon, or a planet, look at it as you would a clock. Use the clock's face as a reference, and note where features begin and end. Try to identify the center of the object's circle. Draw light outlines first — start with apparent features like sunspots, large lunar craters, or planetary ands. Then move on to smaller, fainter features. Lastly, carefully shade in areas until you're satisfied with the details.

If, on the other hand, you've chosen a deep-sky object, begin by comparing its size to that of the entire field of view. Is it half as big as the field of view? One-third as large? One-fifth? Try to capture this ratio in your drawing.

Sketch the positions of the brightest stars first, and use them as reference points. Once you're satisfied the bright stars on your sketch match what you're seeing through the eyepiece, plot some of the fainter stars. (Some sketchers wait until they've drawn the object before they add any faint stars. Pick whichever sequence seems best to you.)



DAVID J. EICHER

THE RING NEBULA (M57) in Lyra is a bright planetary nebula that's small enough to make a good "first target" for sketchers. Before you start your sketch, note the shape of the nebula (it's not circular), the density of both the ring and the central area, and the positions of the field stars. This sketch was made through a 24-inch Newtonian reflector at f/4 with a 13mm Nagler eyepiece (188x).

Next, add the target object's rough outline. For star clusters, start by drawing the brightest stars and work to the fainter ones. Finally, add the fill shades that define the object's extent. It's easy to go overboard at this point, so go slowly — compare your sketch to the object frequently.

For either solar system or deep-sky objects, compare and contrast features. Choose a pair of features and note:

- whether they're the same height and width
- whether they appear tilted at the same angle
- whether they're the same in terms of lightness and darkness
- how their borders compare
- whether they have the same degree of smoothness
- any differences in color
- where they are with respect to one another

When you're satisfied with the way one pair of features looks, move on to the next.

The big difference between solar system objects and deep-sky objects is that deep-sky objects don't change. The Moon's features also won't change, but enough lunar details exist for a lifetime's worth of sketching. Still, if you observe a deep-sky object through a different telescope or un er dif ferent sky conditions, your view will change dramatically. In such cases, a new sketch may be called for.

A sketch is just a sketch

Your sketches will be more valuable to you if you keep a log. Log entries include the date and time the sketch was made, the telescope and eyepieces you used, and a brief description of sky conditions. Where you put these details is up to you. Your method may consist of nothing more than filling in the blank areas on your sketching form. Or, you can record the details on a separate page, dedicate an observing notebook to sketches, or store them on a computer disk with word-processing software.

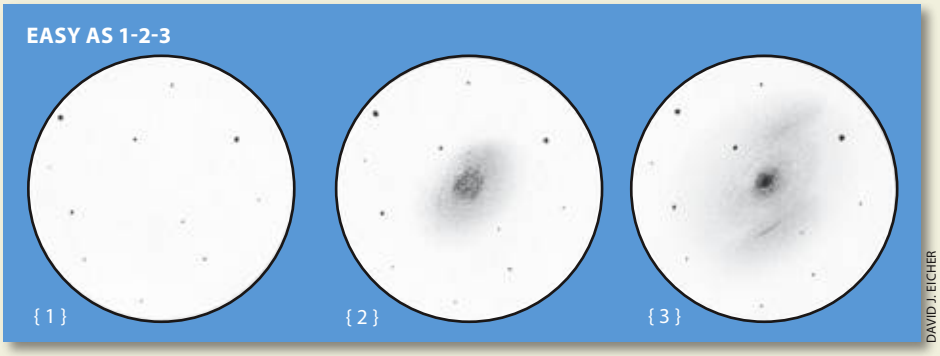
Back inside

After your at-the-eyepiece session, it's certainly permissible to continue to work on your sketch. First, if necessary, clean it up. Remove stray pencil marks or unwanted smudges. A light touch-up to fill in shaded areas or to add color is fine as long as you don't add any detail you didn't see through the telescope.

Some observers make nice, round stars with a black pen or do their smudging at this time. Some also spray a layer of fixative on each sketch to protect it from handling and the Sun's ultraviolet light.

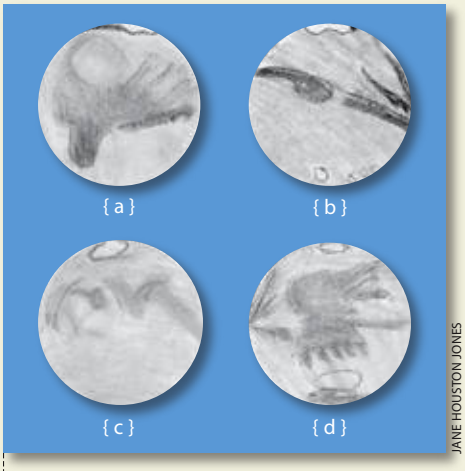
After each session, file your sketches and their desc iptions someplace safe. In a hort time, you'll have an archive to refer ence and share with others — without expensive imaging equipment. Your sketches will comprise a time-lapse "movie" of sorts that shows your improvement as an artist. Along the way, don't forget to send a few of your favorites to *Astronomy*.

ONLINE EXTRA To see other sketches, including a solar animation, be sure to log on to www.astronomy.com/toc



DAVID J. EICHER

SKETCHING A DEEP-SKY OBJECT is easier if you follow a few tried-and-true steps. 1) Draw the brightest stars first, then add progressively fainter ones, triangulating to fix their correct positions. 2) Draw the central disk of nebulosity with graphite (or a soft pencil). With your finger, gently smear the graphite to mimic the object's shape. 3) Finish your drawing by using an eraser and more smearing to match your view through the eyepiece more closely.



JANE HOUSTON JONES

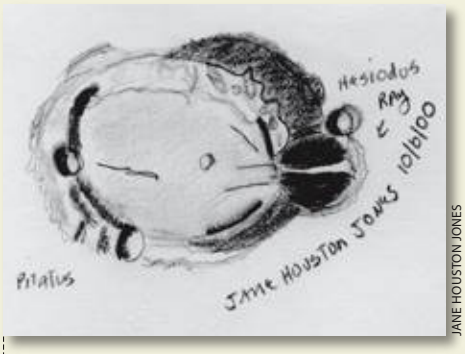
FOUR SKETCHES OF MARS show the Red Planet during its August 2003 close approach. All images were made through a 4-inch Astro-Physics Traveler apochromatic refractor at f/6 using 200x. a) 10h15m UT, August 6, 2003; b) 7h30m UT, August 15, 2003; c) 7h00m UT, August 24, 2003; d) 6h30m UT, August 31, 2003.

JANE HOUSTON JONES

OPEN CLUSTER NGC 7789 in Cassiopeia looked like this through a 12.5-inch Newtonian refractor at f/5.75 with a 9mm eyepiece (202x). Note how Jones differentiated between the bright and faint background stars.

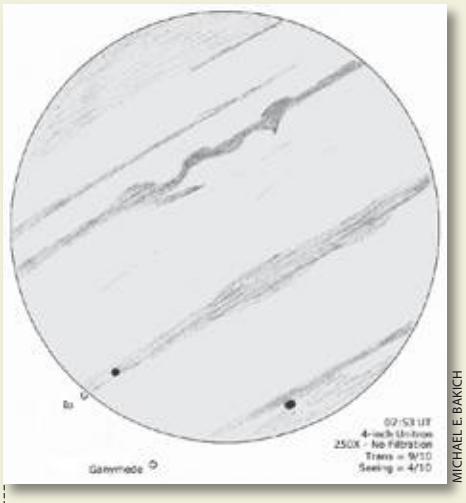
JANE HOUSTON JONES

NGC 205 is one of the Andromeda Galaxy's (M31) companions. This sketch shows the small elliptical galaxy as it appeared through a 10-inch Newtonian reflector at f/7.3 at 142x.



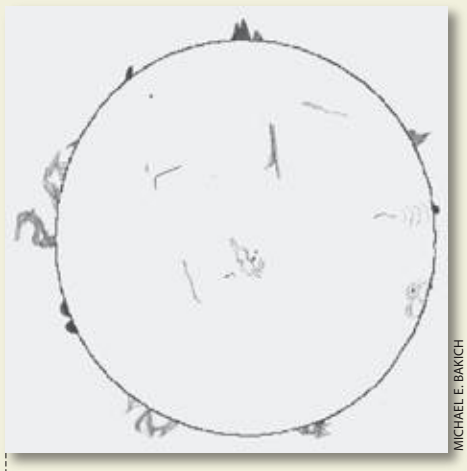
JANE HOUSTON JONES

LUNAR CRATERS Pitatus and Hesiodus were sketched October 6, 2000, at 10 P.M. PDT. At the time, the Moon was 9 days old. Jones used a 10-inch Newtonian reflector at f/7.3 and a 6mm eyepiece, yielding 309x. Pitatus is a flooded, walled plain. Rimae Pitatus, the clefts within Pitatus, are visible. Note the sunrise ray, which breaks through a crumbled wall between Pitatus and the small crater Hesiodus.



MICHAEL E. BAKICH

THIS JUPITER SKETCH shows the shadow transits of Io and Ganymede at 2h53m UT January 8, 2001. The shadows were easy to follow through a 4-inch Unitron refractor at f/15 and 250x. Both satellites also were visible to the lower left of Jupiter.



MICHAEL E. BAKICH

THE SUN displayed changing prominences, sunspots, and filaments September 14, 2000, between 23h11m UT and 23h27m UT. The author used a 0.7Å DayStar Hydrogen-alpha filter mounted on his 4-inch Unitron refractor at f/30 and 60x.

Ask Astro

Planet swap, he lar est planehary ula, new neighbor

PLANET SWAP

If Mars and Venus could swap places, how much brighter would Venus appear from Mars' current orbit? — MELVIN CLARK, WATSONVILLE, CALIFORNIA

Both Mars and Venus are easy to see during the month of November. Mars lies opposite the Sun in our sky November 7, when it shines brightest at magnitude –2.3. You can find the Red Planet climbing in the east as darkness falls these November evenings. Venus is farthest east of the Sun November 3, and appears low in the southwest an hour after sunset all month. It gleams at magnitude –4.3, more than 6 times brighter than Mars, and is easily the brightest point of light in the night sky.

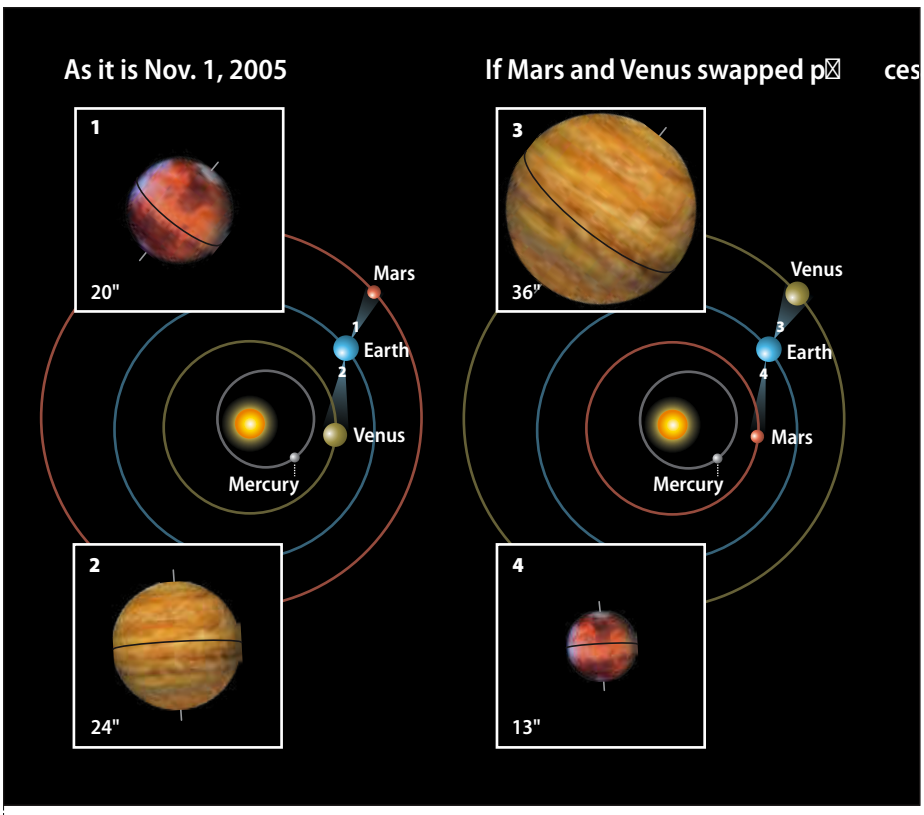
The two objects appear bright for somewhat different reasons, and that plays into what they would look like if they could swap places. Although both planets lie close to Earth — a key brightness factor — Mars shines so brightly now because of the "opposition effect," the tendency of an object to appear brighter when it lies opposite the Sun because all shadows disappear. It's why the Full Moon shines about 10 times brighter than a half-lit quarter Moon.

Venus, because it lies closer to the Sun than Earth does, never reaches opposition. In fact, if you were to look at it through a telescope at greatest elongation, you would see only a half-lit disk. Venus appears so bright largely because its surface is cloaked in highly reflective clouds. The planet reflects 65 percent of the sunlight that hits it, compared with just 15 percent for Mars.

How would this play out if the two planets switched places? Mars would appear dimmer than it does now and Venus much brighter — but it wouldn't much change their ranking among the brightest objects. Mars would shine at magnitude –1.4 and brighten a few tenths more by December. That places it right around the magnitude of Sirius, the brightest star, so it wouldn't drop much in the rankings.

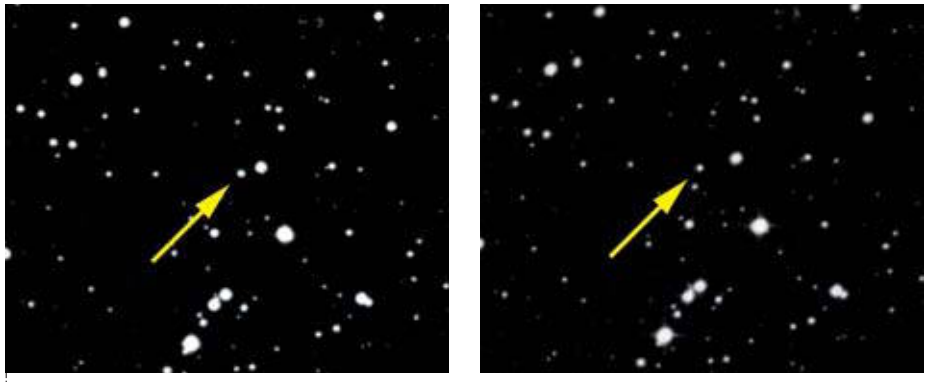
Venus would brighten to magnitude –5.2 and appear 2.3 times brighter than it does now. For those curious as to how bright Venus would have looked if it were to take the place of Mars back in August 2003, when the Red Planet had its best opposition in tens of thousands of years, it would have shone at magnitude –5.8. (Although, keep in mind this is a hypothetical situation — the opposition effect wouldn't actually affect Venus.)

Of course, if Mars and Venus were to trade places, there's no guarantee they would have the same properties. In fact, it's fair to say they likely would be entirely different planets. Venus now has a suffocatingly thick atmosphere in part because it lies fairly close to the Sun. The water it presumably once had evaporated into space, and so the carbon dioxide present stayed airborne. (On Earth, the oceans helped turn carbon dioxide into carbonate rocks.)



IF MARS AND VENUS SWAPPED PLACES, Venus would be brighter and Mars dimmer November 1. In this hypothetical situation, Venus' full disk would reflect sunlight, and Mars' disk would be only half-lit. *ASTRONOMY:* ROEN KELLY

So if Venus moved out to Mars' distance from the Sun, it likely would have retained its water and ended up with a more Earth-like environment, possibly including liquid water on its surface. The planet's atmosphere would have led to a significant greenhouse effect that would keep it significantly warmer than the current Mars. If Mars moved into Venus' orbit, however, it would have lost its atmosphere quickly because its lesser gravity could not hold onto the gases. It would now likely be a warm world lacking an atmosphere — much closer in appearance to Mercury than to any of the other terrestrial planets.
— RICHARD TALCOTT, SENIOR EDITOR



THE SU 'S NEWLY DIUCOVERE NEIGHBOR, SIPS 1259–4336,changes its position in pictures taken a decade apart. The star, located in the southern constellation Centaurus, is roughly 12 light-years away. In these images, orth is up and east is to the left.UKSTU/ESO/ UNIVERSITY OF EDINBURGH, N. DEACON, N. HAMBLY, J. COOKE

THE LARGEST PLANETARY NEBULA

Where is Hewett 1, the largest-known planetary nebula mentioned in "See a star die" (February 2005)? — MIKE McCARVILLE, MAZON, ILLINOIS

The planetary nebula Hewett 1 is about 2° across and is located almost exactly on the celestial equator in Sextans the Sextant at R.A. 10h37m, Dec. –0°18'. The nebula is associated with the very hot white dwarf star PG 1034+001, which has an estimated distance of 500 light-years but with a large uncertainty. The closest known planetary nebula is Sh 2–216, with a well-established trigonometric distance of 425 light-years. Measurement of the parallax of PG 1034+001 will determine whether Hewett 1 is in fact closer.

The nebula is unusual in a number of respects, not the least of which was the method of its discovery. Most planetary nebulae were discovered in images sensitive to the strong emission lines coming from the nebula's excited hydrogen. By contrast, Hewett 1 was identified by emission lines from oxygen in the spectra of many background galaxies and quasars observed a par f the Sloan Digital S y Survey. The nebula's large size caused many spectra to show oxygen's characteristic emission-line signature.

The physical size of the nebula is approximately 2°, which, at its distance, is roughly 17 light-years across. However, astronomers have also discovered evidence of a surrounding halo of ionized gas extending nearly 10°.

The final stages in the evolution of Sun-like stars as they transform from red giants into white dwarfs is not well-understood. Hewett 1 is important because of its association with a member of a class of white dwarfs that so far has not been known to show evidence for the existence of planetary nebulae. Further study of Hewett 1, together with more sensitive searches for planetary nebulae surrounding other hot white dwarfs, will advance our understanding of the violent and rapid (on a stellar timescale) phase of stellar evolution that leads to the creation of white dwarfs.
— PAUL HEWETT, DISCOVERER OF HEWETT 1, CAMBRIDGE UNIVERSITY, ENGLAND

NEW NEIGHBOR

The March 2005 issue mentioned a newly discovered stellar neighbor, SIPS 1259–4336. How do astronomers use parallax to determine if a star is a close neighbor of the Sun? — DAVID SALVIA, SANTA BARBARA, CALIFORNIA

The two images (above) that appeared in the news story "New star found near Sol" show the star's proper motion, not its parallax. Proper motion is the apparent movement of a star across the sky year after year. It results from both the star's movement through space and our own. In the same way, as you drive down the highway, nearby objects — such as road signs — appear to pass by fast, whereas distant objects — such as mountains — seem to move slowly. The two images of the new star were taken 10 years apart.

A large proper motion is a great way to discover a nearby star, but it's not a good way to measure distance. The size of the proper motion depends on both the star's distance from us and its motion through space. For example, the stars Alpha (α) Centauri and Mu (μ) Cassiopeiae have almost equally 8arge prope motions — but u C s is nearly 6 times farther away than Alpha Cen. Lhe proper mot ons a pear equally large because Mu Cas moves through sp ce nearly 6 times faster. Alpha Cen has a large proper motion primarily because it's close to us; Mu Cas has a large proper motion primarily because it moves through space so fast.

To determine a star's distance, astronomers measure its parallax — the small shift that occurs in a star's apparent position as Earth orbits the Sun. The larger the parallax, the closer the star is to Earth. Right now, astronomers have measured a rough parallax for the new star, but, by early next year, they hope to have a precise one. Then we'll know exactly how close our new neighbor is. **— KEN CROSWELL,** BERKELEY, CALIFORNIA

Send your questions via e-mail to: askastro@astronomy.com; or write to)sk Astro, P. O. BoO 1612, Waukesha, WI 53187. Be sure to tell us your full name an, where you l e. UnfoE unate y, we cannot answ r all qu s tions submitted.

The Red Planet is making its best appearance until 2018. Now is the time to see it. /// BY MICHAEL E. BAKICH

Set your sights on Mars

Mars is back again, and it's now as big

and bright as it will be until 2018. So, not only will veteran observers be watching the Red Planet, it also will be in the public eye. Reporters are scrambling to get their facts straight, telescope sales are increasing, and Mars-related visits to Astronomy.com are nearing record numbers. There's even a hoax e-mail circulating that says Mars will appear as large as the Full Moon to the naked eye, and then it will disappear! Fortunately, that's not true. But how will the Red Planet's appearance compare with the one it made 2 years ago?

August 27, 2003, was a banner day for Mars. Thousands of telescopes treated millions of viewers to the biggest and brightest apparition of the Red Planet ever. Because this year's outlook isn't as good technically, many observers haven't put Mars in their 2005 celestial planner. While it's true this opposition isn't classified as a "great" one, in some ways it actually offers a better chance for Northern Hemisphere observers to view Mars.

The numbers game

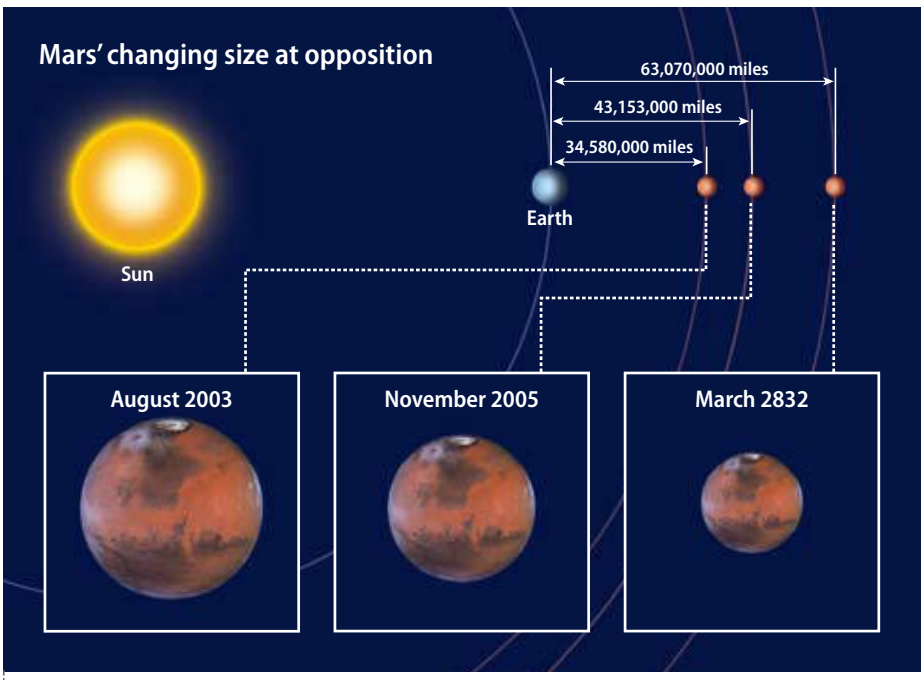
Astronomers concentrate on observing Mars during times near its opposition. At each opposition, Mars rises in the east as the Sun sets in the west, making it visible all night long. Some oppositions are more favorable for observing because Mars' orbital position places it closer to the Sun (and therefore Earth) than at other oppositions. The 2005 martian opposition occurs at 8h20m UT (3:20 A.M. EST) November 7.

The point of closest approach between Mars and Earth occurs a week before opposition. At 4h21m UT (12:21 A.M. EST) October 30, Mars lies 0.46 astronomical unit, or 43,153,000 miles (69,449,000 km), from Earth. Closest approach marks the date when Mars' diameter is greatest — 20.2". This size is nearly 5" smaller than in 2003, but larger than at any other opposition since 1988.

Luckily, Mars appears higher in the sky this year for Northern Hemisphere observers. In 2003, Mars' declination at opposition was –15°46'. For an observer located at 40° north latitude, Mars reached only a bit more than 34° above the southern horizon. (Because celestial objects rise in the east and set in the west, they reach their highest point when they're directly south.)

RALF VANDEBERGH

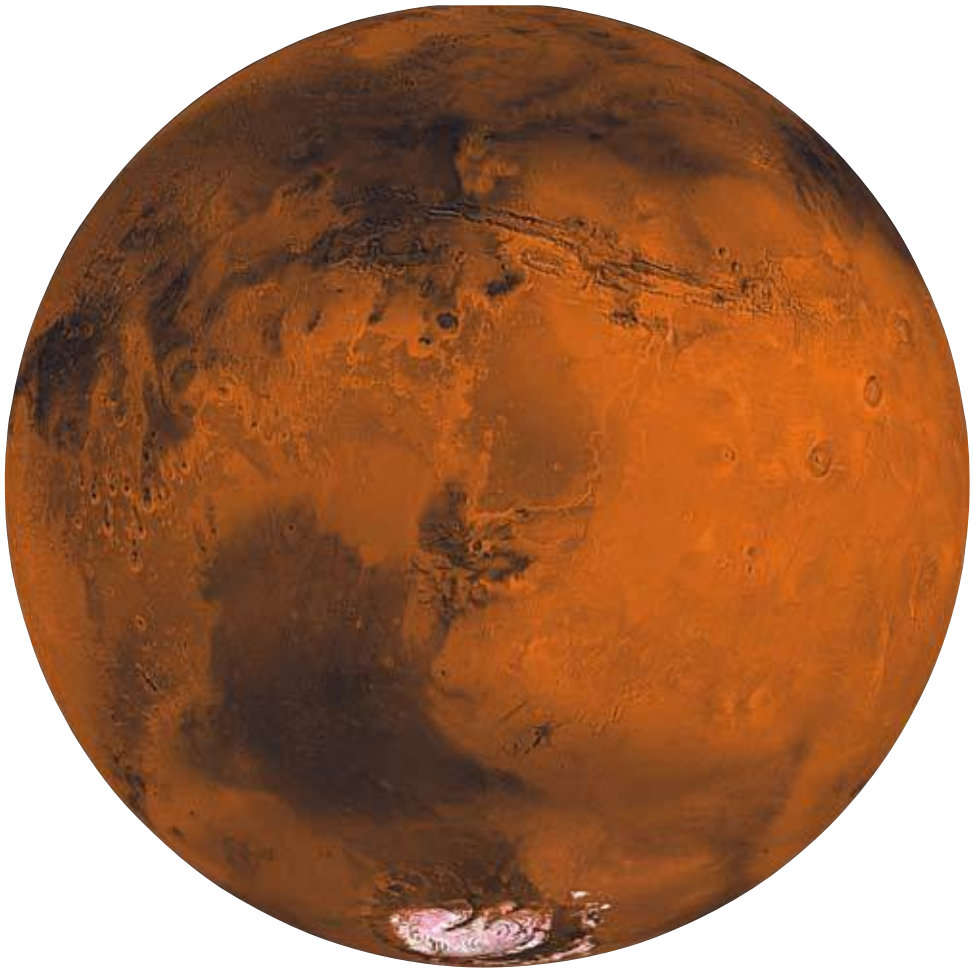
EVEN A SMALL MARS shows detail. This image was taken June 27, 2005, at 4h59m UT with a 10-inch Newtonian reflector at f/45 and an Atik ATK-1HS CCD camera. At that time, Mars' diameter was only 9.1". Several large albedo features — and a bright south polar cap — are visible.



ASTRONOMY: ROEN KELLY

ALTHOUGH FARTHER AND SMALLER than it appeared in 2003, Mars in 2005 will appear much larger than during its worst opposition, more than 800 years from now.

Michael E. Bakich *is an associate editor of* Astronomy.



THIS GLOBAL COLOR VIEW OF MARS is a legacy of the Viking 1 orbiter. The view is centered at 20° latitude and 60° longitude, with south up, which mimics the view through a telescope. The white north polar cap sits at the bottom, the Valles Marineris canyon system is above center, and four huge Tharsis volcanoes appear at right. USGS

This year, Mars' declination at opposition November 7 reaches 15°52'. The same observer can see the Red Planet climb nearly 66° high in the south. This difference in altitude — 32° — is significant because the thickest, most distorting part of Earth's atmosphere lies near the horizon. As you look at objects higher in the sky, less atmosphere lies between your eyes and the object. So, having two-thirds of the sky below the planet adds to this year's adventure for Northern [illegible] mi[illegible] dhere observers.

Dust off your scope

Beginning amateur astronomers often ask what telescope is best for observing Mars. The answer is simple: the bigges[illegible] . The fac[illegible] [illegible] that Mars looks better through a large telescope is no surprise — everything looks bette924hro[illegible] gh a bigger scope.

But don't despair. Believe it or not, a good view of Mars depends more on the quality of your sky than on the size of your telescope. Mars is a small object — not e[illegible] rly as big as most star clusters, nebulae,

UPCOMING MARS EVENTS

OPPOSITION	CLOSEST TO EARTH	DISTANCE[1]	MAX. SIZE
Dec. 24, 200 [illegible]	Dec. 18, 2007	54.79 (88.17)	15.9"
Jan. 29, 2010	[illegible] an. 27, 2010	61.72 (99.33)	14.1"
Mar. 3, 2012	Mar. 5, 2012	62.62 (100.78)	13.9"
Apr. 8, 2014	Apr. 14, 2014	57.41 (92.39)	15.2"
May [illegible] , 201	May 30, 2016	46.78 (75.28)	18.6"
July 27, 2018	July 31, 2018	35.78 (57.59)	24.3"

[1] Distance is in millions of miles (millions of km)

/// GLOSSA Y

ALBEDO FEATURE — a bright or dark observable region on Mars.

ALTITUDE — the angle a celestial object lies above (or below) the horizon. Altitude is measured from 0° (on the hori- on) to 90 (at the zenith).

ARCSECOND — (also called second of arc) $^1/_{3,600}$ of 1°; designated 1". One arcsecond is the angle a quarter appears 3 miles away. Mars' maximum angular size in 2005 will be 20.2".

APERTURE — the diameter of the main lens or mirror in a telescope.

APHELION — the instant in a planet's elliptical orbit when it is farthest from the Sun; occurs once per orbit.

APPARITION — the period of time en a cel[illegible] s ial body may be observed. The current Mars apparition lasts from September 2004 to June 2006.

CENTRAL MERIDIAN — an imaginary line joining Mars' poles, and dividing the planet's visible disk in half.

DECLINATION — an angle measured north or south from the celestial equator (Earth's equator projected into space) to a point on the sky. Declination ranges from 0° to 90°; it is positive if the object is north of the celestial equator and negative if it is south.

DIRECT MOTION — a planet's apparent (west to east) motion through the sky.

HORIZON — the circle where the celestial sphere intersects Earth at every point; where the sky and Earth meet.

LIMB — the edge of a celestial object.

MAGNITUDE — a number that represents the amount of light emitted by a celestial object.

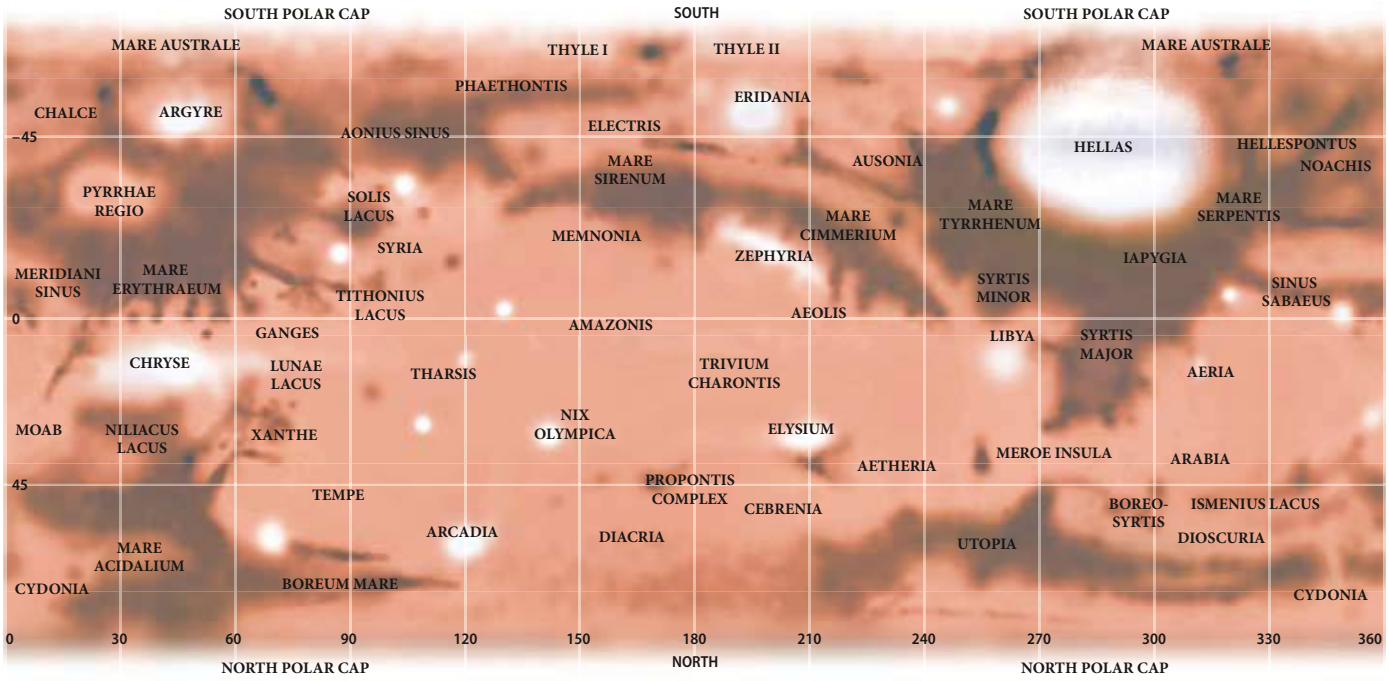
OPPOSITION — the position of a celestial object when it is opposite the Sun in the sk a[illegible] visible all night.

PERIHELION — the instant in a planet's elliptical orbit when it is closest to the Sun; occurs once per orbit.

RETROGRADE M TION— the false (east to west) apparent motion of a planet through the sky. For Mars, this occurs when it's near opposition as Earth (orbiting faster) passes it.

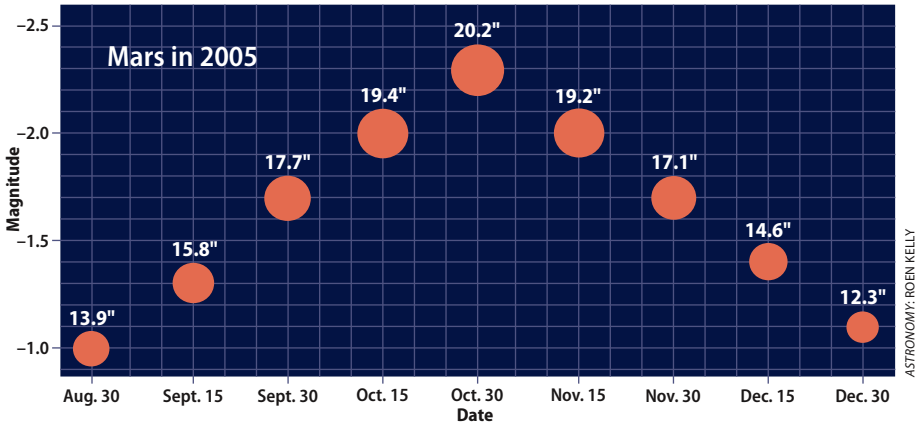
ZENITH — the overhead point.

Mars' albedo features



ASTRONOMY: ROEN KELLY

MARS' ROTATIONAL RATE is 37.4 minutes longer than ours. So, if you observe Mars at the same time each night, its markings will shift westward 9.11° per night. In a little more than 5 weeks, therefore, Mars slowly rotates backward one full turn. You can also wait for Mars' rotation to bring an unseen albedo feature into view, or a visible feature to its central meridian. See the chart below and plan to observe some major features. Because Mars rotates once every 24.62 hours, in 1 hour it will rotate 14.62°.



ASTRONOMY: ROEN KELLY

HOW BIG AND BRIGHT Mars will be depends on the date you choose to observe it. This graph shows how Mars' apparent size grows before and shrinks after opposition.

LONGITUDE OF MARS' CENTRAL MERIDIAN

DATE	LONGITUDE	LOOK FOR
Oct. 4	122.7°	Arcadia Planitia
Oct. 7	95.6°	Tharsis Montes
Oct. 10	48°	Xanthe Terra
Oct. 13	41.5°	Chryse Planitia
Oct. 16	14.7°	Meridiani Sinus
Oct. 19	348°	Noachis Terra
Oct. 31	241.9°	Utopia Planitia
Nov. 3	215.5°	Elysium Planitia
Nov. 9	162.7°	Amazonis Planitia
Nov. 18	90°	Solis Lacus
Nov. 24	30°	Niliacus Lacus

or galaxies — so it requires high magnification for details to be visible. If the air above your observing site is unsteady, you won't be able to use high magnification.

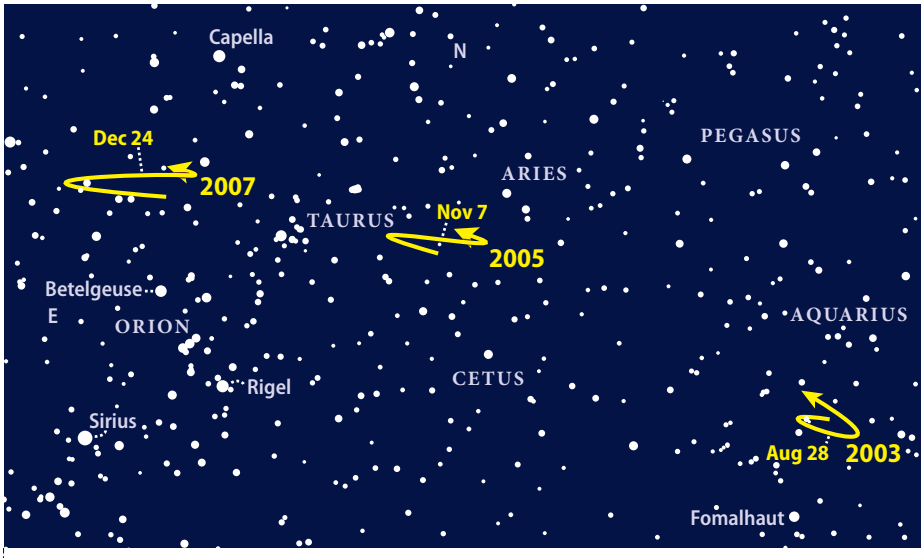
Mars also is a bright object. This fact makes the amount of light pollution at your observing site irrelevant. Earthly lights won't hinder your observations. In fact, some ambient light actually is welcome when you observe the Red Planet. A white light off to your side and lighting up your surroundings will cause your daytime vision — which is superior to your night vision in both resolution and color sensitivity — to kick in.

The land area of Mars is approximately equivalent to Earth's dry land area. Because of the Red Planet's smaller size, the thin martian atmosphere, and the lack of erosion, surface features there tend to be more pronounced than those on Earth.

With a 4-inch or smaller telescope, you can observe the large r a b do e t res. These include Syrtis Major, the Hellas Basin, Solis Lacus, and the South Polar Ice Cap, which will be tilted toward Earth. Don't confuse He las with the polar cap Hellas is a round, bripht feature — an impact basin with lots of bright dust and sometimes fog or clouds. Especially when seen near the limb, it can look like a polar cap. In all cases, c mpare your view wi h the map above.

cope out th dust

When Mars' peri elion occurs near opposi tio , backyar aetronomers (and planetary scientists) wonder if storms will be visible. Because the Red Planet's atmosphere is too



ASTRONOMY: ROEN KELLY

RETROGRADE MOTION is a false motion we see when Earth passes Mars. Compare Mars' retrograde motion and sky positions for the oppositions of 2003, 2005, and 2007.

thin to support all but the flimsiest cirrus clouds, martian storms mean only one thing — dust.

Dust storms on Mars occur more frequently when the planet is nearest the Sun. Astronomers have observed two types: major storms, which are localized to a martian desert region; and planet-wide events. We've observed only a handful of the globe-covering dust storms; the first was in 1924. Then none were observed until 1956. Predicting a martian dust storm is difficult, but if one erupts, the most likely time is October 15 through November 15.

Forecast: cloudy

With a 6-inch or larger telescope, you can observe several different types of clouds in Mars' atmosphere. One type is seasonal clouds, which are related to the planet's seasonal heating and cooling. This causes frosts to sublimate and condense.

You also can observe discrete clouds, which stick to one area as the planet rotates. Most discrete clouds are in Mars' northern hemisphere during spring and summer. To observe them, a blue filter works best.

Orographic clouds are a form of discrete clouds. These are water-ice clouds caused by wind passing over the peaks of martian mountains and volcanoes. To observe high-altitude orographic clouds, use a blue or violet filter. A green filter works best on low-altitude orographic clouds. Try both.

Finally, you can observe morning and evening clouds. These are bright, isolated patches of surface fog seen at sunrise or sunset. Don't confuse such a sighting with ground frost. You can tell if what you're looking at is a morning cloud if it disappears in a few hours. Frost may last all day. Evening clouds are generally larger, and there are more of them. They grow as the martian night approaches.

Capture Mars

Amateur astronomers create the best images of Mars when its apparent size is largest. But don't wait for Halloween night to begin imaging the Red Planet. Today's high-quality telescopes, filters, and cameras — coupled with good image-processing techniques — will allow you to take good images of Mars when the planet's diameter is as small as 10".

If you're considering imaging Mars, think about taking a number of images over a long period of time. A series of images with the same martian longitude on its meridian may show differences in seasonal clouds, polar-cap size, or even the development of dust storms.

Head outside now

The best time to observe Mars is *tonight*. Once every 26 months, Mars appears bright in our sky, but some of these appearances — like this one — are better than others. Take advantage of the planet's size and brightness. Mars won't look this good for 13 years. So, head out to a science center or observatory, contact your local astronomy club, or point your scope at the Red Planet, and take a good, long look.

/// TECHNIQUES

#8 Light yellow	#56 Light green
#12 Yellow	#80A Blue
#15 Deep yellow	#25 Red
#82A Light blue	#38A Dark blue
#21 Orange	#47 Violet
#23A Light red	#58 Green

USE FILTERS TO ENHANCE MARS

Each time I observe Mars, I take a look through my chosen eyepiece to center the planet, assure a good focus, and use image steadiness to decide on a starting magnification. Usually, that's the last point I view Mars without a filter.

Color filters are misunderstood by many amateur astronomers for two reasons: either they don't understand what the filter should show or they find the view unappealing. Regarding the first point, color filters don't show changes in color, despite their name. Rather, they show changes in brightness.

Filters enhance hard-to-see details on Mars. They do this by increasing or reducing the contrast between features. Filters amplify subtle differences between adjacent regions by transmitting (keeping visible) one color while absorbing (blocking) others.

Because Mars is predominantly red, a red filter will accentuate the planet's ruddy deserts, while simultaneously darkening its greenish regions. Viewing Mars through a green filter will produce the opposite effect.

Most color filters work better when used with larger telescopes, which collect more light. If you observe through a 4-inch or smaller telescope, use an orange (#21) filter. It will darken albedo features and make the surrounding desert regions stand out. Telescopes with apertures between 4 and 10 inches should be paired with a light red (#23A) filter, and 10-inch or larger scopes benefit most from a dark red (#25) filter. If you use these darker filters, you'll see the surface contrast increase. Because less light is getting through, however, you also will need a bigger scope.

Color filters can make noticeable differences when you observe Mars, but they do take some getting used to. Be patient, and you'll be amazed at how much more detail you'll see. — *M. E. B.*

Taking high-resolution lunar photos demands patience and ruthless determination. /// BY ROBERT BURNHAM

Shoot the Moon

The Moon looks like it ought to be the easiest thing in the sky to photograph. After all, it's big and bright, and it's loaded with detail. But as experienced astrophotographers can tell you, while it's easy enough to take a so-so photo of the Moon, it's surprisingly hard to take an excellent one. As with a lot of astrophotography, the devil's in the details.

Charge-coupled device (CCD) cameras have changed astrophotography, and lunar imaging in particular. Shooting the Moon on film involves enlarging the Moon's image in your telescope and camera combination. It often means using eyepieces to project the lunar image into the camera, and it is woefully dependent on having good (that is, steady) seeing.

But with a CCD camera, Moon images are naturally magnified because the lens is larger in proportion to the light-sensitive chip than it is to 35mm film. And while seeing remains important, the ability of a CCD camera to snap dozens of images quickly gives the astrophotographer many options. For example, you can examine each image you take in a burst and discard the blurry ones — and you can stack several images together electronically to smooth the pixellation effect.

Telescope

All astroimaging begins, not with the camera, but with the telescope. The type is less important than the mounting, which should be stable and designed for equatorial tracking (to compensate for Earth's rotation). While it is possible to hold a basic digital camera up to the eyepiece of a Dobsonian-mounted reflector and snap a Moon photo, the results are unimpressive.

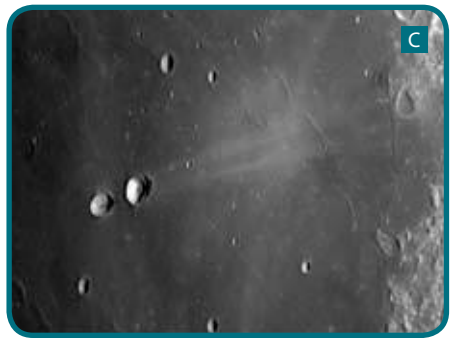
Robert Burnham *is a senior editor of* Astronomy.

ANTHONY AYIOMAMITIS

[A] THE RHEITA VALLEY is a scar from the impact that created the Imbrium basin on the Moon's southeast side. Flying debris carved these two segments that meet each other at a shallow angle.

DAMIAN PEACH

[B] EVENING SUNLIGHT catches the trio of large craters on the western shore of Mare Nectaris. Top to bottom, they are Catharina, Cyrillus, and Theophilus.



DAMIAN PEACH

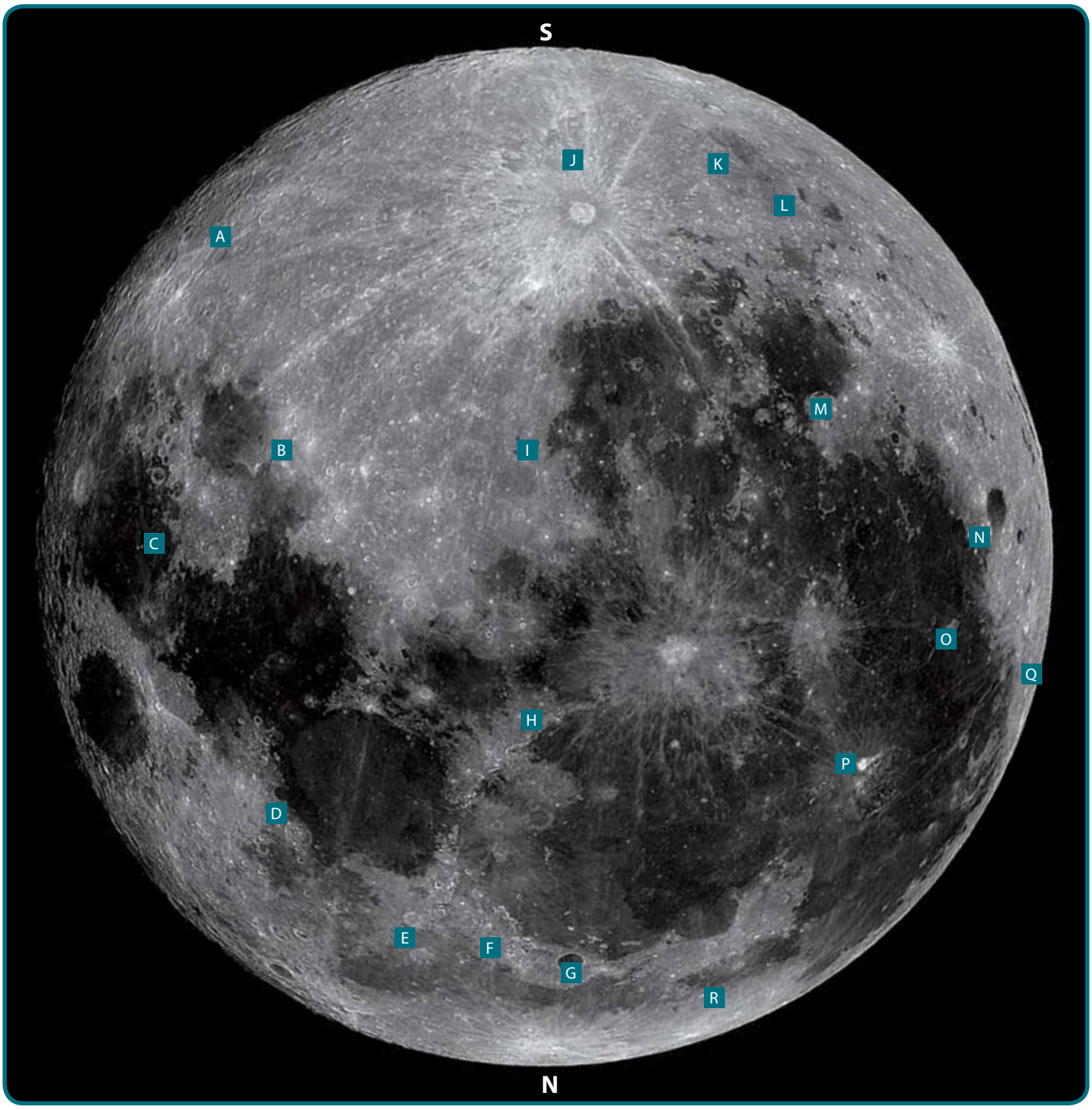
[C] AN OBLIQUE IMPACT scattered two "comet tails" of ejecta from the crater Messier, the left hand one of the pair. Both lie in Mare Fecunditatis and are seen here a day or two past Full Moon.

It's far better to use an equatorially mounted telescope, preferably one whose drive can run at the lunar rate. This keeps the Moon in the camera's field of view while you fiddle with the focus and choose the areas to shoot.

Camera

CCD cameras vary in chip size, and the best ones generally have the largest chips. Besides size, what matters most is ease of operation in the dark, rapid cycling and downloading times, and low noise in the images. Sensitivity is important, but the Moon is a pretty bright target.

The biggest difference between film and CCD imaging is the small field of view delivered by CCD cameras coupled to backyard telescopes. While these are great for isolating an interesting feature or two,



DANIEL B. PHILLIPS

FULL MOON taunts every astroimager. It hinders deep-sky photos and is itself remarkably difficult to capture. But properly processed, its almost infinite shades of gray tell a story of violent impacts and sheets of now-hardened lava. South is at the top in all images.

they don't take in much landscape. If the goal is to show all of Mare Nectaris, for example, astroimagers have to make a mosaic, using software to paste together views from individual frames.

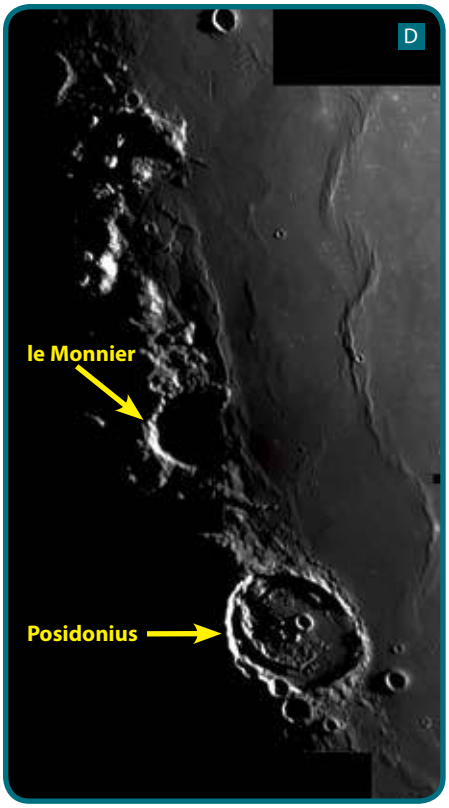
This can be done manually with image-processing software, such as Adobe *Photoshop* and *GraphicConverter.* Other specialized software exists that's designed to mosaic frames into larger images.

Moonlight

The light of the Moon is sunlight, of course, but the Moon isn't a very smooth reflector. The eye tends to reduce the range in brightness that occurs naturally across the lunar disk, but cameras always detect it faithfully. At First Quarter Moon, for example, the "hotspot" at the limb is amazingly bright compared to an equal area located near the terminator, which divides day and night.

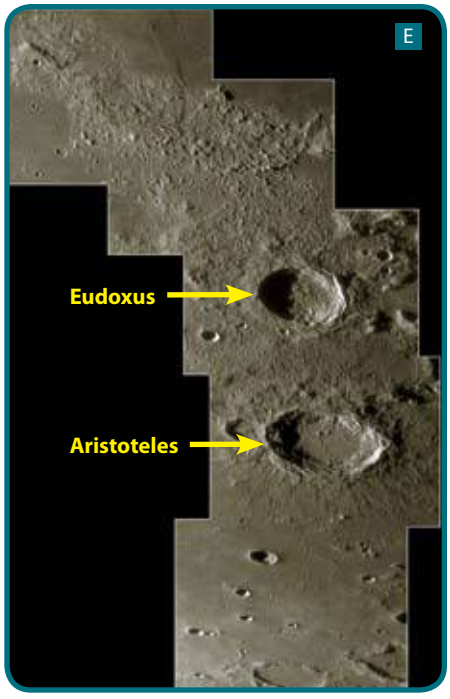
In the darkroom days, astrophotographers making a print would overexpose faint areas and underexpose brighter areas that normally would "burn" in. This effect reduced the biggest brightness variations across the print. With CCD cameras, this effect is accomplished primarily with adjustments you make using computer software. In both cases, the effect is the same.

— *continued on page 83*



JIM PHILLIPS

[D] THE EDGE OF NIGHT is about to engulf the crater Posidonius and the eastern shore of Mare Serenitatis. Parallel to the shore is Serpentine Ridge, where the mare lava buckled as the basin floor under the mare subsided.



PAOLO LAZZAROTTI

[E] DUE NORTH OF SERENITATIS lies a range of hills that are part of the basin rim. The craters Eudoxus (top) and Aristoteles show generally smooth floors filled with impact melt and debris from the formation of other craters nearby.

JAMIE COOPER

[F] CUTTING A CHANNEL through the lunar Alps, the Alpine Valley is a block of ground that dropped between two geologic faults. Running down the center is a rille that this image just captures.

CHRISTIAN VILADRICH

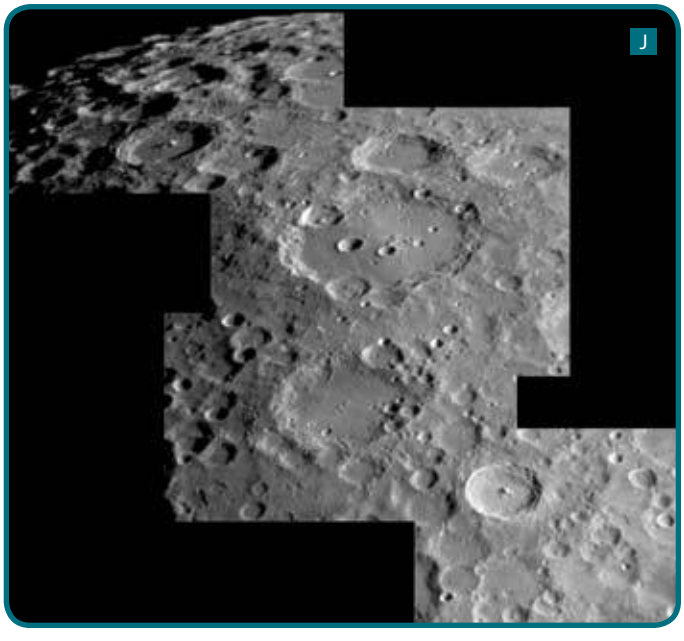
[G] "THE DARK LAKE" is how some lunar observers refer to Plato, a flooded impact crater in the lunar Alps. Around Full Moon, Plato appears especially dark in contrast to the surrounding mountains.

PAOLO LAZZAROTTI

[H] THE SOUTHERN SHORE of Mare Imbrium hosts some of the most magnificent features on the Moon — from Copernicus (right) eastward past Eratosthenes (center) and following the graceful curve of the Apennine Mountains.

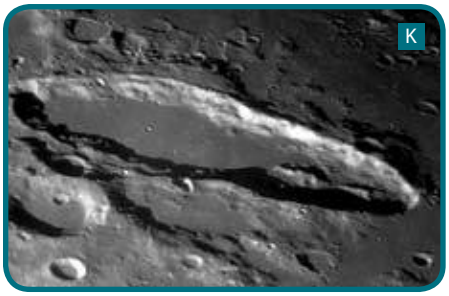
RALF VANDEBERGH

[I] DOWN THE CENTER OF THE MOON run several impressive craters that have been altered to varying degrees by geological forces. Arzachel (top) shows little change, but Alphonsus (middle) and Ptolemaeus have been flooded.



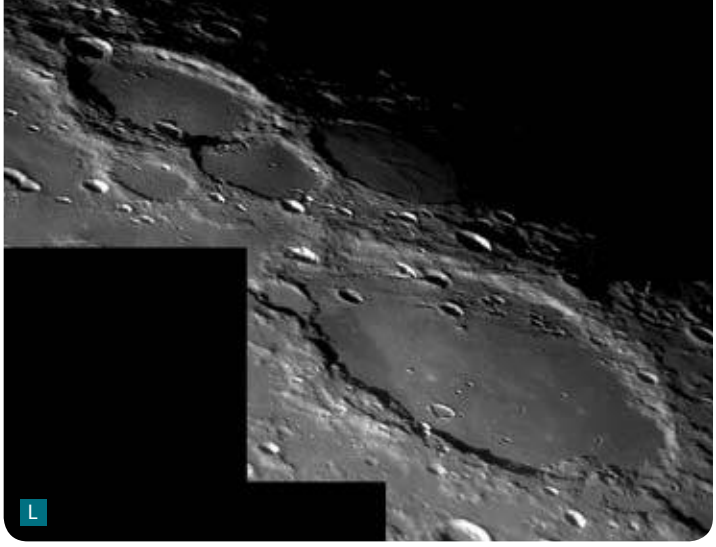
DAMIAN PEACH

[J] RUNNING SOUTH TO THE POLE, the tangled highlands show the Moon's most ancient face. Tycho (bottom) however is quite "new," being only about 100 million years old.



DAMIAN PEACH

[K] THE OVAL CRATER SCHILLER resulted from a shallow-angle strike by a large chunk of debris thrown out by a basin-making impact.



DAMIAN PEACH

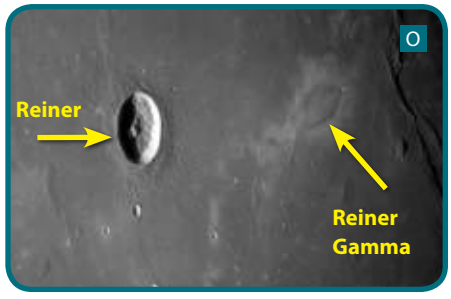
[L] BETWEEN SCHICKARD (bottom right) and Phocylides (top left) lies a field of craters that have been altered by volcanic action and blanketed by debris.

DAMIAN PEACH

[M] LYING ON THE NORTH SHORE of Mare Humorum, Gassendi shows a lot of modification. Note the melted wall on the mare side, and the shallow, lava-flooded floor, cracked with rilles.

DAMIAN PEACH

[N] X MARKS THE SPOT on the floor of Hevelius, where two rilles cross near the crater's center. As with many craters adjoining a mare, the floor of Hevelius shows signs of flooding.

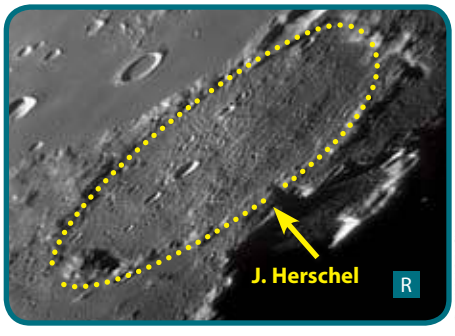


DAMIAN PEACH

[O] REINER GAMMA is a strange swirl on Oceanus Procellarum. Intense magnetism from unknown causes has prevented the Sun's charged particles from darkening the mare surface there.

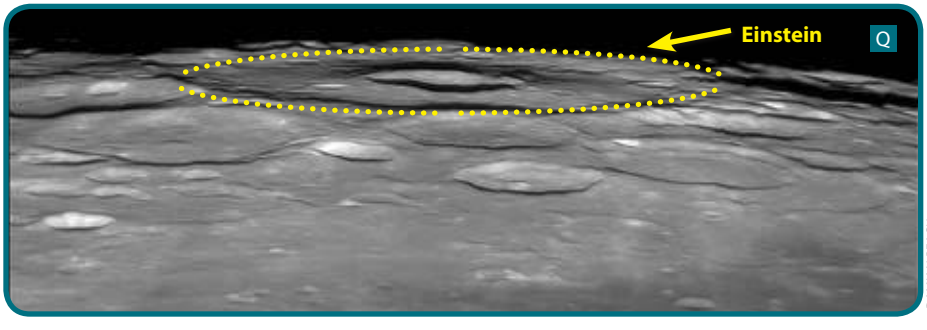
DAMIAN PEACH

[P] ARISTARCHUS (left), Herodotus, and Schröter's Valley lie atop the Aristarchus Plateau. Lunar geologists suspect parts of the plateau saw lava fire-fountains when the Valley was new.



DAMIAN PEACH

[R] ASTRONOMY'S OTHER HERSCHEL is the ancient crater J. (for John) Herschel, named for William Herschel's son. J. Herschel lies on the Moon's far northwestern limb and is difficult to photograph.



DAMIAN PEACH

[Q] A GENIUS IN HIDING, the walled plain Einstein with its central crater lies on the far western limb of the Moon and is often out of sight. This view shows the large crater as an orbiting astronaut approaching from the east at sunrise might see it.

— continued from page 81

Whatever imaging technique is involved, outstanding astrophotos result from painstaking care and considerable practice. The Moon makes an excellent target to shoot for, offering lots of challenges — and a face that never looks exactly the same.

While M33, for instance, will never change from one image to the next — unless you get lucky and catch a supernova — every lunar image you take will appear a little different. Perhaps tonight the lighting will be just right to show the field of domes around the crater Marius. Or maybe you can assemble a series of images over many months showing how Copernicus changes appearance as the Sun rises and sets over it.

Astrophotographers tend to curse the amount of light the Moon scatters through the sky for robbing them of their deep-sky treasures. But the Moon itself offers a wonderfully varied skyshooting target. All you need is the desire to go for it.

astronomics™ . . . our 27th year.

We've been e pingrp v " chv–se the right telescope since 1979. We ha e the experience (a staff total of over 150 years of exp rienc zusiug an s lling telescopes) to help *you* pick the telescope that fits yy r needs (and your budget). And, with our seven-figure inventory, we can usually sh you the right scope, right away, from the hundreds of elescopes we tock.

We started *a t o om* over 26 ye" s ago ecause we lo ed astro omy,

Celestron *SkyAlign* go-to scopes start at a low $279.

You don't need to know the Pleiades from Polaris to find your way around the sky with a **Celestron SLT** go-to telescope. With Celestron SkyAlign technology, just point your SLT at any three of the 50 brightest lights in the sky (3 stars, or 2 stars and a planet), and the SLT will find the planets and over 4,000 deep space objects for you *automatically.* A few anonymous points of light are all you need to find your way around the skies ike a pro.

$339

80mm Celestron NexStar 80 SLT

Celestron SLT no-guesswork go-to scopes are available in these sizes:

NexStar 60, 60mm refractor **$279**00
NexStar 80, 80mm refractor **379**00
NexStar 102, 102mm refractor **479**00
NexStar 114, 114mm reflector **399**00
NexStar 130, 130mm reflector **439**00

Each has two eyepieces, a red dot finder, motor drives, stainless steel tripod, NexStar computer, software to control the scope from your computer, and more.

A 6" go-to SCT f r $999. Now *that's* a good deal.

Th **Celestron Advanced Series** 6" Schmidt-Cassegrain gathers 44% more light than a more ex ens–ve 5" Maksut v to show you more faint objects, with 20% h gher es°lu ion. Its faster f/ratio means a wider field and brighter images, too.

This 6" SCT has an adjustable height tripod with 2" steel legs, heavy-duty equato ial mount wVth d al motor d i es premium Starbright XLT multicoatings, 25mm Plössl eyepiece, 6 x 30mm finder, and a NexStar computer to find and track over 45,000 stars and objects for you *automatically.*

Celestron 6" f/10 Advanced go-to **$999**

No-guesswork Celestron *GPS* Schmidt-Cassegrains.

It's easy to find your way around the sky with a GPS-equipped **Celestron CPC**. Just point it at any three of the 50 brightest lights in the sky (3 stars, or 2 stars and a planet or the Moon), and the CPC will find over 45,000 deep space objects for you at the touch of a button.

You don't have to memorize a star chart to use a CPC. The GPS system and a few anonymous lights in the sky are all you need.

Celestron 8" f/10 CPC800 **$1899**

Celestron CPC Schmidt-Cassegrains are available in the following sizes:

8" **CPC800**, Starbright coatings **$1899**00
8" **CPC800X**, XLT coatings **1999**00
9¼" **CPC925**, Starbright coatings **2349**00
9¼" **CPC925X**, XLT coatings **2499**00
11" **CPC1100**, Starbright coatings **2599**00
11" **CPC1100X**, XLT coatings **2799**00

Each has all the visual and photographic features you want and need, plus Celestron's best multicoated optics ever.

Big Celestron 11" scopes start at only $1699.

Celestron Advanced Series 11" German mount Schmidt-Cassegrains have almost twice the light-gathering of an 8" telescope. They show you more deep space wonders than an 8" SCT on a fork mount – *for about the same price*

The 11" Advanced Series teles opes available from our tock include:

C11S, German equatorial mount **$1699**00
C11S (XLT), as above, XLT cLatingM... **1979**00
C11S-GT, go-to German equatorial **1999**00
C11S-GT (XLT), go-to, XLT coatings . **2279**00

The C11S and C11S (XLT) have a heavy-duty equatorial mount, adjustable height tripod with 2" steel legs, slow motion controls, setting circles, a 40mm Plössl eyepiece, and a 9 x 50mm finder. Starbright multicoated optics are standard. State-of-the-art XLT multicoatings on the C11S (XLT) give you 16% higher light transmission for even brighter images. An optional dual-axis drive is available for both scopes.

11" Celestron C11S **$1699**

The go-to C11S-GT and C11S-GT (XLT) have dual motor drives and a NexStar computer to automatically find and track over 45,000 stars and objects for you.

At only 29 lbs. for the heaviest component, each is easy to transport and set up. And, best of all, they are *all* very affordable. A *big* telescope no longer costs a fortune, thanks to Celestron.

Are these great values?

The low prices of these **Konus** telescopes are downright amazing.

Clnsi er the 90mmq **Konusmotor-90** f/11 refractor, to the left. It has a good-quality equatorial mount, a battery-powered motor drive, and *two* 1.25" Plössl eyepieces. We sell dozens of t is sv ye, because it's a great value at only $209!

$209

3.5" f/11 Konus refractor

The **Konusky-200** 8" f/5 reflector, above right, has a heavy duty equatorial mount with a steel leg tri-od, *dual-axis* DC motor drives, *two* 1.25" Plössl eyepieces, an 8 x 50mm finder-cope, and a polar axis finder. It's a lot of telescope for only $519!

8" f/5 Konus reflector **$519**

You bet they are.

The **Motormax-150** ¼" M ksutov, above right, has the same heavy duty mount and accessories as the 8" reflector. It's a terrific value at its low price of only $799, well below the cost of other large Maks.

6" f/12 Konus Maksutov **$799**

A binoviewer *with* eyepieces for only $199.

Other binocular viewers for an SCT can cost over $1200 without eyepieces. A **Burgess Optical** Binoviewer costs only $199, *including* two eyepieces. Viewing with two eyes through the Binovi wer's multicoated BaK-4 prisms shows you up to 40% more detail than you can see through a single eyepiece.

$199

Designing a binoviewer isn't rocket science, and modern computerized manufacturing makes this one both good *and* inexpensive. We've sold over 400 of these to very happy buyers. Try one and see the 40% *you've* been missing.

I am a very inexperienced amateur in the astronomy hobby. I have dealt with a lot of companies and businesses in the past and have come to the conclusion that most do not "practice what they preach" as the saying goes. Being not completely satisfied as a customer is more the norm in this ay and age and sadly, we have come to except it as the normal in our daily dealings. In my dealings with you folks however, I am very happy to say I am a satisfied customer! I appreciate your help and, above all – your honesty! It is so very refreshing to be treated fairly when it would be so easy for you get away with not doing so due to my ignorance about how things should be in this new (and expensive) hobby of mine. It is the sort of treatment that brings customers back over and over again with a feeling that they are glad to support your business. It is a good feeling to know that when things do go wrong, as they do now and then, you can be counted upon to handle it fairly a d honestly. This sort of performance will make your company thrive in the future.

Customer Quote of the Month #164

Award-winning solar observing for the pri e f an eye ie e!

$499

For about the cost f a single premium eyepiece, the sub-Å stro hyd " n alpha filter of the **Coronado PST** (Personal Solar Telescope) lets you see the ever-changVng drama of s tar flares nd prominences (not just sunspots, as with ordinary solar filters).

Popular Science Magazine named the ST "Th Best of What's New" in the field of aviation and space for 2005.

A go-to scope only $209.95?

Go-to telescopes take the guesswork out of findin–é your way arou d the skies. They move your scope *automatically* to the object you want to see, so you find your way around the skie like a veteran nly a few minutes after you set up a go-to scope – even if you don't know Polaris from the Pleiades.

$209.95

Bushnell NorthStar 3 3" f/9rq go-to reflector

Hard to believe. BUSHNELL

The 3" **Bushnell NorthStar 3** go-to reflector has everything you need to get started in astronomy, in- c ding *two* eyepieces, a Barlow, a red dot finder, and a talking computer with up to 2r,0 stars and objects it can locate for you. Want a great value in a go-to starter scope? Look no further.

A William Optics Petzval-type semi-apo for $448.

Anot er man factu er's 4" Petzval-type apo optical tube costs $3600 and is worth it.

The **ZenithStar 66 Astro** from **Wil iam Optics** has a 66mm Petzval-type mul icoared 4 lens b ective with an ED glass element for very nearly color-free performance. It costs only $448 and is *more* than worth it.

$448

William Optics ZenithStar 66mm semi-apo OTA

I comes with a ro–atabl 2" Crayford focuser, 1/10th wave accuracy 2" star diagonal with a *diel ct ic* mirror for 99% reflectivity, retractabl lenscshadey dust caps, and a soft carry case.

Its removable L-shaped mvunti shoe fits photo tripods and SCT piggybacks. It makes a super finder for your main t lvscope a d an optically outstanding second scope for travel, nature study, and spur-of-the-moment astronomy.

an ty rea *unbiased* equipment reviews by astronomers just like you? Find thvm ar

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Red dot or bull's eye, we have a finder for you.

Telrad **$39.95**

Red dot and bull's eye finders seem to project dots and ci cles o red light on the dome of the sky. They make t eas to aim your telescope or star hop fr obj¼ct to object.

LTke the or g nal and best-selling Telrad above (we've sold literally thousands of these), all of these finders come with batteriesqand ba es. W also carry thnee dozen conventional magnifying finders.

Hery's a list of the non-magnifying illuminated finders that we keep in stock:

Burgess, MRF multiple reticle **$69**00
Celestro , Star Pointer red dot **29**95
Rigel, QuikFinder bull's eye **39**–5
TeleVue, Qwik-Point red dot **29**95
Starbeam re do **205**00
Starbeam red dot for TeleVue only **2 5**0
Starbeam re dpt f r CTs..... **45**–
Telrad, bull's eye **39**95
Vixen red d t for Vixen scopes only..... **79**00

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We ct lly stock TeleVue

Otherl may *say* they carry **TeleVue** scopes, *but we ac u ally ee TeleV e sco es i stock.* Dozens of them.

P 101 **$3595**

A few of the TeleVue scopes we ha e "nystock for iumediate shipmen are li ted below. These are basic optical tubes only, with dust covers and carrying case, for use with your own accessories.

TV-60, 2.4" f/6 apo **$795**00
TV-76, 3" f/6.3 apo **1275**00
TV-85, 3.35" f/7 apo **1680**00
TV-102, 4" f/8.6 apo **22 0**0

Complete packages (for use on your own mount) with a st r d - agonal, 20mm Plössl eye- piece, mountizg ring, dvst ve s, and c rryi g cas , are also in stock and listed below.

TV-76, 3" f/6.3 apo **$1675**00
TV-85, 3.35" f/7 apo **2080**00
TV-102, 4" f/8.6 apo n **2635**00
Renaissanc 4" f/8.6 brass **2935**00
N -101,4" f/5.4 Petzval apo **3595**00

nd more than just TeleVue telescopes, we stock hundreds and hun reds of TeleVue eyepieces and accessores for immediate shipment.

Does your dealer? We ship Meade from *our* stock to save you time/money.

Meade 8" LX200 GPS **$2299** *freight paid*

A lot of Meade dealers don't stock Meade telescopes. They have Meade ship them to you. That means you pay sales t t f you live in California.

A California resident doesn't pay sales tax on a 7 to 12 LX200 that ships from our stock.

And, if a dealer has to order a scope from the factory, it may take days before he can even find ¼ut if it's in stock at Meade. We tell you immediately if we have a scope for you, and you won't have to wait days for the factory to ship.

Plus, if you live in the midwest or on the East Coast, it often takes an order two to four days longer to arrive when it's shipped from a West Coast warehouse¼ than it does when it's shipped from our warehouse in the center of the country.

Here are the *freight-paid* prices for the LX200s w usual y ship from our inventory to the 48 st test ¼ ve you time and mo y:

7" LX200 Maksutov **$2799**00
7" LX200 Maksutov, w/UHTC **2949**00
8" LX200 Schmidt **2299**00
8" LX200 Schmidt, w/UHTC **2474**00
10" LX200 Schmidt **2999**00
10" LX200 Schmidt, w/UHTC **3234**00
12" LX200 Schmidt **3799**00
1 " vX200 Schmidt w/UHTC **4094**00

The most popular telescope website . . .

Numbers don't lie! In August, according to the leading inde- pendent intern t ratin service, **www.astronomics.com** was still the most visited telescope store on the web (for what seems like the u teenth month in a row).

astronomics.com visits wer even ranked ahead of the major telescope manufacturers' sites.

One of the "big two" telescope suppliers told us we've probably sold more high end scopes over the years than any other telescnp st re un the world I tru , our website is one reason why.

Try **astronom cs.com** and see why more people visit our site for the right information, the right products, and the right prices.

We're your Meade Tier 1 stocking dealer . . . get accessories fast from www.astronomics.com/meade.

Being a Meade Tier 1 stocking dealer means we keep mos¼ Mead scores and accessories in our own seven-figure inventory. You don't have to wait days for your local dealer to have MeaVeSship a scope or accessory to you.

In many cases, we ship from our own stock, saving you time and money – and in most cases saving you sales tax.

Below is a *partial* list of the Meade accessories that we s ip for free. v nuif ou order smaller items that are not on this list, our freight is free if your Meade order totals more than $99.

4-lens 2x Barlow, 1.25", Series 5000 ... **$159**00
4-lens 3x Barlow, 1.25", Series 5000 ..... **159**–0
4-lens 5x Barlow, 1.25", Seri°s 500 ..... **159**00
4-lens 2x Barlow, 2", Series 5000 ..... **9**9
snar Plan ary Imager **149**–0
Deep Sky Imager **299**00
Deep Sky Im ge– Pr **399**00
Deep Sky Imager Pro, with filters **499**00
LXD-75 equatorial mount **499**00
26mm 1.25" Series 5000 Plössl **99**00
32mm 2" Series 5000 Plössl **149**00
40mm 2" Series 5000 Plössl **199**00
8-24mm 1.25" Series 4000 zoom **219**95
16mm 1.25" Series 5000 Super Wide **179**00
2 mm 1.25" Series 5000 Super Wide.... **1 9**0
24mm 1.25" Series 5000 Super Wide **249**00
28mm 2" Series 5000 Super Wide **279**00
34mm 2" Series 5000 Super Wide **299**00
40mm 2" Series 5000 Super Wide **399**00
4.7mm, 6.7mm, 8.8mm, or 14mm 1.25" Series 5000 Ultra Wide **199**00
18mm 1.25" Series 5000 Ultra Wide **279**00

24mm 2" Series 5000 Ultra Wide **$399**00
30mm 2" Series 5000 Ultra Wide **449**00
#644 1.25" flip mirror **149**95
#647 2" flip mirror **249**95
9mm 1.25" illuminated reticle **149**95
9mm 1.25" illuminated rvticle w/co d **129**95
12mm 1.25" astrometric reticle **119**95
ETX terrestrial observer's kit **99**00
ETX celestial observer's kit **99**00
ETX amateur astronomer's kit **199**00
ETX deluxe observer's kit **299**00
ETX deluxe astrophltographer's kit **299**00
LXD75 celestial observer's kit **199**00
LXD75 deluxe observez's kit **299**00
LXD75 deluxe astrophotographer's kit ... **299**00
LX90 astrophotographer's kit **2 9**0
LX200/RCX400 astrophotographer's kit **349**00
LX200/RCX400 deluxe astrophoto kit **499**00
#929 2" UHTC star diagonal for SCTs ... **119**95
#930 2" UHTC refractor star diagonal **119**–5
f/6 3 reducer/corrector for SCTs **129**95
f/3.3 CCD reducer/corrector for SCTs **149**95

21st century Celestron go-to . . . at a 1984 price.

$1399

If you fondly remember the original orange-tube C8, the **Celestron NexStar 8i Special Edition** will bring back the good old days – at a low price that's straight out of the 1980s!

It combines a modern anodized version of Celestron's vintage orange and black paint scheme, the convenience of a go-to computer with no-guesswork *SkyAlign* technology, and the bright images of Starbright XLT multicoatings – Celestron's best ever.

The best part? This 21st century telescope is available for less than the price of an 8" Celestron from 1984 that didn't even have a computer.

Telescopes have changed a lot over the past 20 years. But the value and optical performance of a Celestron C8 have always been standards you can rely on.

A better d atonal makes any scope be ter.

$298

really good star qiagonal can increase the light transmission *and* improve planetary contrast and detail when compared with thn so-so diagonal usually supplied with most new telescopes.

Typical of the new breed of premium diagonals we carry is the new **William Optics** 2" star diagonal above. Its first surface mirror is made of premium quality p 0th wave°a curacy ultra-stable *quartz* instead of ordinary plate glass. Instead of a single layer of 97% reflective aluminuW, it has 30-layer 99% reflective *dielectric* coatings. Complete with a 1.25" eyepiece adapter, it's our part #W2DQ an costs o ly **$298**.

There's also a quartz version with threads to fit a Schmidt-Cassegrain rear cell (our art #W2DQSCT) forzoxly $318.

Here is a *partial* list of the star diagonals we stock:

Celestron 2" mirror **$84.50**
Denkmeier Pow r Switch for SCTs **389.00**
As above, wi h dielectric d agonal .**509.00**
Power Switch for refractors **499.00**
As axove, with dielectric diagonal **619.00**
eade#918A 1.25" prism **42.95**
–929 2" UHTC mirror for SCTs **19.95**
#930 2" UHTC mirror for refractors **119.95**
Questar 1 25" mirror fo 3.5" Questars ...**225.00**
2" mirror for 7" Questars **445.00**
akahashi0.95" compression ring prism .. **59.50**
1.25" compression ring prism **107.00**
2" mirror for SQ-106 only..... **2 .00**
2" 1/10th wa e mirror **334.95**
TeleV e1.25" enhanced mirror **140.00**
1.25 Ever r te dielect ic mirror..... **190.00**
1.25" 60° Everbrite d elecrri mirror..... **210.00**
2" enhanced mirror .....rz.....**210.00**
2" Everbrite dielectric mirror **290.00**
2" Everbrite die ect ic mirror for SCTs .**275.00**
ixen1.25" flip mirror **80.00**
2" mirror **240.00**
2" mirror for SCTs **220.00**
William Optics 2" enhanced mirror **130.00**
2" enhanced mirror for SCTs .....°.....**139.9**
2" dielectric mirror **199.95**
2" dielectric mirror or CTs **229.00**
2" quartz dielectric mirror **298.00**
2" quartz dielectric mirror for SCTs **318.00**

A Premier ETX is almost as easy as GPS!

ETX-125PE **$1095** *freight paid*

All you have to do to find your way around the sky with your new 3.5" to 5" **Meade Premier ETX** Maksutov-Cassegrain is tell it your zip code.

Level North Technology automatically levels the optical tube, finds North, sets the time, and moves to two alignment stars. Center the red dot finder on those stars. Then tell your ETX which of the 30,000+ objects in its memory you want to see, and the scope takes you there automatically.

Using an ETX is almost as easy as using a GPS system, but a new ETX Premier costs a lot less!

We ship Meade RCX scopes from our stock.

Meade modified Ritchey-Chrétien scopes put virtually the same optical design as the Hubble Space Telescope into affordable and portable scopes for amateur astronomers. The 10" and 12" scopes often ship from our stock, so we save you time over dealers who have them drop-shipped from Meade (and if you're in California, we save you the sales tax).

The 10" **RCX400 10"**, frt paid **$5149**00
The 12" **RCX400 12"**, frt paid **6799**00
The 14" **RCX400 14"**, frt paid **9299**00
The 16" **RCX400 16"**, frt paid **16,399**00

GPS and Level North Technology make aligning on the sky *automatic*. You start observing in minutes. Standard equipment UHTC optics for 15% higher light transmission, High Precision Pointing, Permanent Periodic Error Correction, a 2" UHTC star diagonal, and a 2" 24mm Ultra Wide eyepiece – the list of features just goes on and on.

Meade 12" f/8 RCX400 Ritchey-Chrétien **$6799** *freight paid*

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From the East Coast to Central California, these club-run observatories serve amateur astronomers as well as their communities. /// BY PHIL HARRINGTON

Bringing the stars down to Earth

DAVID HARTSEL

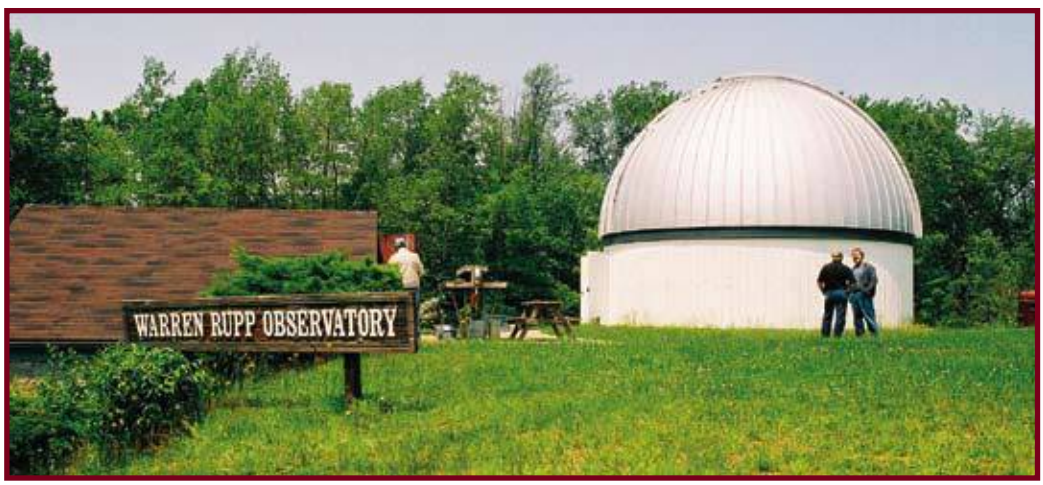
"THE BIG BLUE BEAST" at Warren Rupp Observatory is a 31-inch f/7 Newtonian reflector that took more than 5 years for local amateur telescope-makers to perfect.

Most amateur astronomers recognize Mauna Kea (Hawaii), Palomar (California), and Kitt Peak (Arizona) observatories. But hundreds, perhaps thousands, of smaller observatories lie scattered across the country. In fact, there may be an observatory in your own town. While some observatories are affiliated with colleges and universities, school systems, or museums, most are owned and operated by local astronomy clubs. Not only are these facilities used and enjoyed by club members, but they also have extensive community outreach programs that enable anyone to enjoy views of the heavens.

Warren Rupp Observatory in Ohio, Rolnick Observatory in Connecticut, and Fremont Peak Observatory in California are three such club-run facilities.

WARREN RUPP OBSERVATORY

LOCATION: Hidden Hollow Camp, south of Mansfield, Ohio
RUN BY: Richland Astronomical Society
WEB SITE: www.wro.org



DAVID HARTSEL

THE CAMPGROUND surrounding Warren Rupp Observatory provides a dark-sky setting for observers in central Ohio.

Warren Rupp Observatory

Warren Rupp Observatory is one of the most impressive amateur astronomical facilities in the country. Hidden Hollow Camp is used year-round by scout groups and other young people's civic organizations, and features several activity buildings and small cabins.

For amateur astronomers, however, the centerpiece of the camp is Warren Rupp Observatory. The 30-foot (9 meter) domed building houses a 31-inch f/7 Newtonian reflector, affectionately referred to by members as "The Big Blue Beast." Visitors are awed at their first sights of this huge instrument and become even more impressed when they learn amateur astronomers made the telescope's optics.

In 1968, local amateur telescope-maker Norman Oberle, along with Jim Thomas and other area amateurs, procured a 31-inch mirror blank that had been rejected as an optical flat for the McMath-Hulbert Solar Observatory atop Kitt Peak.

Together, Oberle and Thomas labored more than 2,000 hours during the course of 5 years to grind the 235-pound (107 kilogram) fused quartz blank into a parabolic mirror. After it was aluminized, the mirror was mounted in a fiberglass-coated

DAVID HARTSEL

OBSERVERS RIDE a motorized lift to the "Beast's" eyepiece. Sights through this massive telescope rival those captured in astrophotographs.

cardboard tube and placed on a temporary alt-azimuth mount. Unfortunately, the setup lasted only 4 years before the tube cracked under the mirror's weight.

The optics lay in storage until 1981, when Oberle returned to a Richland Astronomical Society meeting at Hidden Hollow. The following year, Oberle offered to donate the mirror to the club if members could build a suitable telescope and observatory to house it. The club jumped at the opportunity. A fund drive was organized, with a large part of the donations coming from club member Warren Rupp. The Warren Rupp Foundation continues to support the observatory today.

Club members chose an open-truss tube for the 31-inch telescope, because the increased airflow speeds optical cooling, which ensures clear observations. The 18-foot-long (5m) optical-tube assembly was mounted on an English cross-axis equatorial mount. Assembled, the entire instrument weighs an estimated 7,500 pounds (3,400 kg). After 3 years of planning and construction, Warren Rupp Observatory was dedicated in 1985.

Observing through such a colossal instrument is exhilarating. Images appear tack-sharp, with wonderful contrast and clarity. Some say visual astronomy is a cerebral experience because the view through a telescope only faintly resembles what astrophotographs capture. That's not the case with a 31-inch telescope! The telescope's huge aperture helps each view through it look sharp and full of detail. In fact, even getting to the eyepiece of this behemoth is an event. Observers must get into a motorized lift, which then is driven under the focuser and raised to the eyepiece.

Today, Richland members use the 31-inch scope for a variety of observing programs and activities. The surrounding camp offers amateurs in central Ohio a tiny dark-sky oasis where they can commune with other hobbyists.

In addition to using the scope for personal projects, club members open the observatory to the public on the first Saturday of every month, to campers each week camp is in session, and to private groups by appointment. Norman Oberle, who passed away in 1996, undoubtedly would have been thrilled to see so many people enjoying his telescope.

ROLNICK OBSERVATORY

LOCATION: Westport, Connecticut
RUN BY: Westport Astronomical Society
WEB SITE: www.was-ct.org/wasobs.htm

A 40-FOOT-TALL (12m) tower built in the 1950s to house U.S. Army radar equipment is home to the Rolnick Observatory today.

THIS COMPUTER SETUP was added to Rolnick Observatory when the club installed the new go-to mount.

THE 12.5-INCH REFLECTOR, recently placed on a go-to mount, is used by club members for personal observing projects and during weekly open houses.

CARL LANCASTER PHOTOS

Rolnick Observatory

Located on a hill in the northeastern corner of Westport, Connecticut, Rolnick Observatory rests on the site of a former Nike missile radar-tracking station built by the U.S. Army in the 1950s. After the Army closed the facility in 1963, the land and buildings were turned over to the town.

The two most prominent structures on the site, a pair of 40-foot-tall (12m) towers that originally held the radar apparatus, remained unused until 1967. That year, the town erected a domed observatory on top of one of the towers to house a 12.5-inch f/4.8 Newtonian reflecting telescope that Gerald Rolnick, a local resident and amateur astronomer, had donated to the school system.

Although the telescope was put in place then, its use was minimal, and the observatory soon fell into neglect. Rolnick moved out of the area, and the telescope was removed and put into storage for safekeeping.

Eight years later, local physics teacher Fred Bump learned about the observatory and, along with a band of local residents and students (myself included), began its resurrection. Within a year, the tower and observatory were restored, the telescope's optics were refurbished and recoated, and Rolnick Observatory reopened to the public. Shortly afterward, team members formed the Westport Astronomical Society.

The 12.5-inch reflector remains the crown jewel of Rolnick Observatory, and society members use it regularly for personal observing projects and to host weekly open houses. The society opens the observatory doors every Wednesday and Thursday from 8 P.M. until 10 P.M. — weather permitting — to let anyone interested view through the instrument. Special sessions also are held for community groups, scout troops, and other organizations by appointment.

Several years ago, the club augmented the 12.5-inch telescope with the purchase of a 25-inch f/5 Newtonian reflector. The 25-inch scope is taken out during open houses in the spring, summer, and fall, making it the largest publicly accessible instrument of its kind in the state. Recently, the club placed the 12.5-inch scope on a go-to mount.

In addition to the dome, the club uses two adjacent buildings. One is "the warm room," where members can thaw out during an all-nighter or catch up on their sleep. A second building, the Fred Bump Education Center, is used for club meetings and public events.

More than 30 years after its founding, Rolnick Observatory continues to be put to good use by society members and the community. The club provides speakers and materials to teachers and invites student groups to explore the night sky. Members also run an annual Messier marathon and special sessions for eclipses and meteor showers. Rolnick Observatory is one of the most active amateur astronomical observatories in the northeast.

Phil Harrington *is the author of the new observing guidebook* Star Watch*, which is published by John Wiley & Sons.*

FREMONT PEAK OBSERVATORY

LOCATION: Fremont Peak State Park, San Juan Bautista, California
RUN BY: Fremont Peak Observatory Association
WEB SITE: www.fpoa.net

PAUL BRADSHAW

FREMONT BOASTS "the Challenger," a 30-inch f/4.8 Newtonian reflector. A rolling roof and a side "garage door" open for viewing the southern sky.

Fremont Peak Observatory

Fremont Peak State Park in southern California is home to one of the most dynamic amateur astronomical observatories in the country. The Fremont Peak Observatory Association, an informal organization that doesn't hold official meetings, focuses its energy on observing, presenting public programs, and caring for the observatory's equipment, including the prize 30-inch f/4.8 "Challenger" Newtonian reflector.

Kevin Medlock and a small band of amateur telescope-makers built the Challenger in the early 1980s. When the telescope was complete, the group contacted the California State Park Service to see if the group could construct an observatory on park grounds. The agency agreed, and the group started raising funds for the project. Thanks to some $25,000 raised selling equipment donated by Celestron, members constructed an observatory with a roll-off roof on a ridge 2,780 feet (847m) above sea level adjacent to a park ranger's residence. Medlock and his fellow telescope-makers dedicated Fremont Peak Observatory August 30, 1986.

The building consists of two rooms: an observing room that houses the Challenger telescope, and a lecture hall, which also serves as a dormitory for members pulling all-nighters. The observing room's roof slides over the top of the lecture hall, giving the telescope good views in all directions. Because the southern sky is often where the action is, the room's south-facing wall includes a modified garage door, which, when open, makes it possible to aim the telescope all the way to the horizon. Even though the observatory is at latitude 36.76° north, the door allows observers to see the spectacular southern globular cluster Omega Centauri (NGC 5139).

Like the "Beast" in Ohio, the Challenger is an open-truss instrument mounted on an English cross-axis equatorial mount. Although cross-axis mounts are not popular among amateur astronomers due to their unwieldiness for portable scopes, they are sturdy because their polar axes are supported at both ends.

As with all equatorial mounts, a cross-axis mount can twist a telescope into some very inconvenient viewing angles. To remedy this problem, the Challenger's designers incorporated a clever feature that lets observers rotate the secondary mirror to three different positions in order to make the eyepiece more accessible.

Although this sounds like a simple solution, it is anything but: The optics must be collimated properly in not one but three independent directions. This is a difficult task, but the design and execution work flawlessly, with optical alignment remaining true at all times.

In addition to the Challenger, Fremont Peak Observatory is home to several smaller, portable instruments. For public nights, the club brings out a Hydrogen-alpha solar scope as well as 6-, 8-, and 10-inch Newtonian reflectors. These scopes also are brought to community schools for outreach programs and observing sessions.

Since it opened, Fremont Peak Observatory has hosted thousands of people, from the public and community groups to veteran observers. The observatory is open to the public for viewing and educational programs every Saturday evening from April through October, except on nights closest to Full Moon.

According to Pat Donnelly, president of the Fremont Peak Observatory Association, "A program generally consists of a half-hour presentation on some aspect of astronomy followed by observing through the Challenger."

The club also invites the local public to view special sky events like eclipses and meteor showers from the observatory. Visitors are advised to check the club's web site for the current open-house schedule.

Although Fremont Peak Observatory is used primarily as a tool to educate the public about astronomy, it also is available to association members for their own observing projects. Current projects include detailed observations of globular clusters and galaxies, and finding all asteroids numbered 1 to 100.

/// ENRICH THE LOCAL ASTRONOMY COMMUNITY

These three observatories represent what can be accomplished when local amateur astronomers pool their resources. Club-run observatories are valuable assets to their members as well as their local communities. They do more to inform people about astronomy than most professional observatories because they are more accessible. Viewing events hosted by local observatories stimulate interest and encourage the public to get involved in astronomy.

Find a club near you — or add your club to our listings — at www.astronomy.com/asy/community/groups.

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Vixen's Sphinx mount delivers precision tracking and a next-generation controller. /// BY JEFF MEDKEFF

A telescope mount for the 21st century

We amateur astronomers love high-quality equipment that works as advertised. But if the equipment also is good-looking, there's a higher probability we'll buy it. Based on these criteria, Vixen's newest go-to mount — the Sphinx — is a winner.

The Sphinx is a stylish machine with an intriguing control system. The sleek mount conceals its gears and motors and keeps wires out of the way with a well-designed cable-attachment point. A polar-alignment scope housing and slow-motion controls are built in.

But as elegant and fully featured as the mount appears, the Star Book controller commands the most attention. The nerve center for the mount is a tough plastic console sporting 10 buttons, a color screen, and a live star-chart display.

Star Book

When the telescope arrived, I performed the setup procedure without referring to the instructions. This told me a lot about the mount even before I used it. Thanks to Vixen's careful selection of connectors and an intuitive layout, there's no way you can attach anything incorrectly.

Deciding to press my luck, I powered up the mount and started operating it. Soon, it was as though I'd been using it all my life. The buttons on the Star Book have different functions in different modes, but because a key to the buttons is always displayed on the screen, there's never a question about what they do.

My first night under the stars with the Sphinx was at a public star party. As before, setup was quick and easy. Slewing was fast and reliable, and I never had to stop and think about how to get the Star Book to do something. I was so pleased, I was ready to declare that this mount provides the finest user experience of anything on the market. But my initial enthusiasm was tempered by some of the Star Book's shortcomings.

The first problem cropped up during initialization. At one point in the process, the Star Book instructs you to "point telescope toward right horizon." This instruction makes no sense because there's no such thing as a "right horizon" — or if there is, its location depends on where you're standing in relation to the telescope. The Star Book actually wants you to point the telescope to the western horizon. Although I got it right the first time (by luck), it confused me later until I figured it out.

Also, the display is too bright. During a public star party, where many people are using flashlights and it's impossible to escape from nearby light sources, the Star Book's display is not objectionable. But while hunting faint deep-sky objects in my moderately light-polluted backyard, the display's brightness worked against my dark adaption. This is partly because the brightness and contrast adjustments don't have enough range, and partly due to the Star Book's blue display, a color damaging to dark adaption.

A command gives you the option of having the display turn off up to 300 seconds after the last key stroke, but that still

Jeff Medkeff *is an enthusiastic amateur astronomer, science devotee, and skeptic who observes with a variety of telescopes from Alaska.*

THE SPHINX MOUNT provides a sleek, stable, and accurate platform for up to 22 pounds (10 kilograms) of telescope equipment. Vixen's Star Book controller provides full go-to capability for the Sphinx.

THE POLAR-ALIGNMENT SCOPE (optional) is a big help during setup because it makes polar aligning faster and more accurate. The internally illuminated scope screws into the rear of the right ascension axis.

/// PRODUCT SPECIFICATIONS

VIXEN'S SPHINX MOUNT AND STAR BOOK CONTROLLER

Weight:
Mount — 29.7 pounds (13.45 kg)
Tripod — 10.5 pounds (4.75 kg)

Dimensions:
Sphinx mount — 19.9" by 19.1" by 8.9" (505mm by 485mm by 285mm)
Star Book controller — 7.7" by 5.7" by 1.1" (195mm by 145mm by 28mm)
Tripod extends from 27.5" to 43.3" (70 cm to 110 cm)

Star Book controller:
LCD screen — 4.7-inch (diagonal), 320x420 pixels

Also included:
SX-HAL110 tripod, 4.2-pound (1.9-kilogram) counterweight

Price:
$2,199

Contact information:
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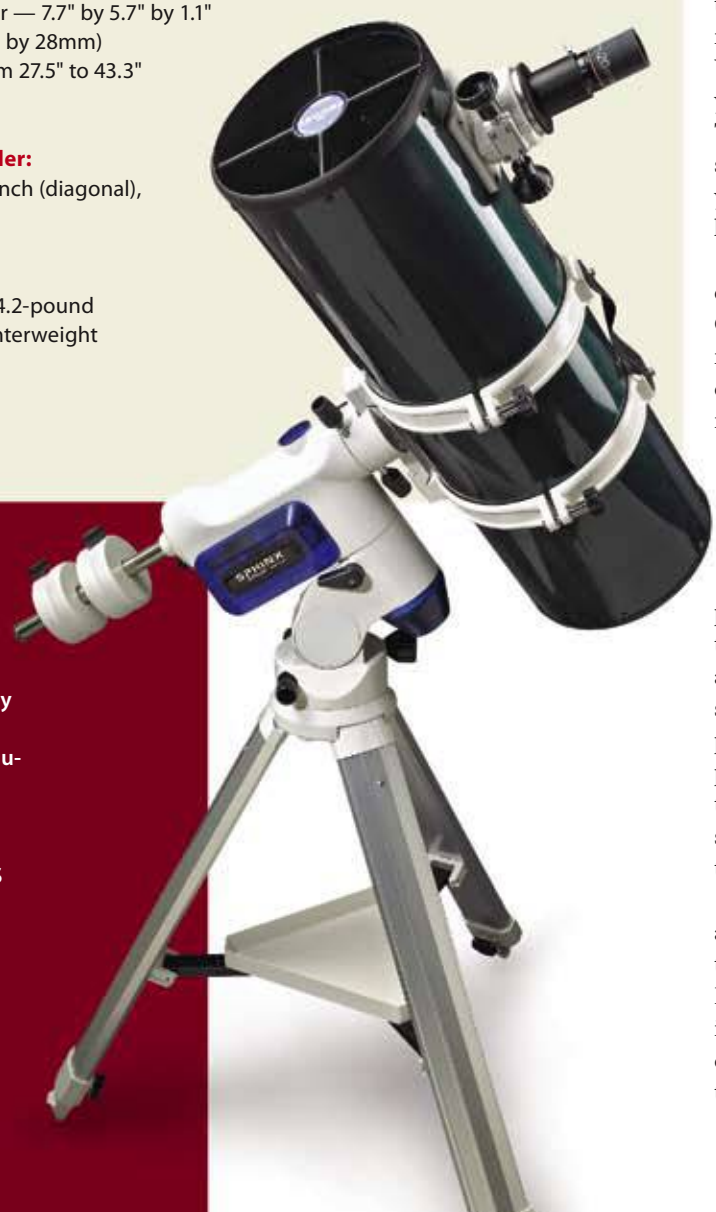
[t] 845.469.8660
[w] www.vixenamerica.com



THE SPHINX MOUNT attaches easily to Vixen's sturdy SX-HAL110 tripod (included). The triangular eyepiece tray is optional. Here, the mount easily carries Vixen's 8-inch R200SS Newtonian reflector (not included), which weighs 11.7 pounds.

leaves a bright screen when it's on. Neutral-density filters included with the Star Book also help by darkening the display.

To its credit, the screen worked well even at low temperatures — I subjected it to a test at –15° Fahrenheit (–26° Celsius) one night — and although the display was a little sluggish, it remained usable.

Getting deeper into the Star Book, advanced observers may find themselves wishing it had a few more features. For example, you can turn constellation labels on and off, but stars aren't labeled at all. Planets are labeled all the time, but the display doesn't show Uranus, Neptune, or Pluto. You can command the mount to go to Uranus and Neptune, but Pluto is missing from the planet menu entirely.

Deep-sky objects are labeled if you put them near the screen's center, but because the chart displays only Messier objects, many of the sky's best targets are missing. You can slew to an NGC or IC object, but you have to know its number in advance. The Star Book reports brightness, type, and size for deep-sky objects, but only when you slew the telescope to them — you can't look this information up in advance.

The Star Book doesn't recognize variable or double stars like Mira (Omicron [ο] Ceti) or Albireo (Beta [β] Cygni). During my test, the Star Book displayed only stars down to about 6th magnitude, but the most recent upgrade to the Star Book's software has fixed this. (See "Updating the Star Book," page 97.)

Connecting the Star Book to a computer also allows you to follow newly discovered comets by uploading their positions. You can't upload asteroid positions, however. Because the dozen brightest asteroids are visible easily with a small telescope, perhaps Vixen will include their positions in a later software upgrade. A problem advanced observers may have is that there's no way to type in a position for something not in the Star Book and have the Sphinx slew there.

The Star Book is so well designed that advanced observers will want it to do more than it's designed to do. In fact, the Star Book is so easy to operate it flirts with user-interface perfection, but its limitations in data display and customization may frustrate some users. Because the Star Book can

be updated easily, I expect future revisions will address these points.

Sphinx mount

I have more good news: The mount is terrific. The tripod is lightweight, stiff, and sturdy, even when its legs are extended. Everything attaches firmly to the tripod and mount. The slow-motion controls can be locked down tight. The clutches are lever-operated and have short throws. In short, everything about the mount is solid, tight, and user-friendly.

With the 8-inch Newtonian reflector included for my review, the mount damped vibrations (from tapping the tube near the eyepiece or focusing) in less than 2 seconds. When I mounted a 17-pound telescope and balanced it with additional counterweights, the damping time increased to 6 seconds. Adding my own vibration-suppression pads cut the time back down to 3 seconds.

Slewing is accurate, with most go-to commands having errors less than 5'. A few of the pointing problems turned out to be position errors in the database — a common malady suffered by all go-to mounts I've encountered.

Slewing also is fast, with a maximum speed of about 2.5° per second. Pointing adjustments are easy to make after the slew is complete. Just press the Star Book's directional buttons. If the mount shows hesitation when changing directions, you can set the backlash compensation for each axis.

The tracking was delightful, keeping objects centered for hours at a time, and having a total periodic error of only 14" (about half the apparent diameter of Jupiter). Periodic error is caused by an imperfection in the mount's drive gear that repeats with each gear turn. If Vixen can manufacture to such fine tolerances consistently, the Sphinx is an extraordinary value because this amount of periodic error is normally encountered only in mounts 4 or 5 times its cost.

Your next mount?

The Vixen Sphinx is a strong contender in the go-to-mount marketplace. As it stands now, the Sphinx is by far the easiest-to-use go-to mount. This makes it the best mount for a beginner or a casual user who wants a high-quality go-to system. And while the Star Book has limits, future software updates to improve usability will help.

I am more cautious in recommending the Sphinx to experienced visual stargazers — Vixen must advance the Star Book's capabilities (more software updates) before power-users will be satisfied.

Those interested in imaging should give this mount consideration, however. An available ASCOM telescope driver, which allows an external computer to control the mount, means the Sphinx is widely supported by software. In addition, imagers will regard the mount's accurate slewing, low periodic error, and relatively low cost as commanding advantages. So, if you have a telescope and need a high-quality mount to drive it, look closely at Vixen's Sphinx.

As Billy Crystal used to say as the character Fernando on the popular television show *Saturday Night Live*, "It's not how you feel, it's how you look, and darling, you look marvelous!" In a word, the Sphinx and Star Book look marvelous. Pull out this pair at the next star party you attend, and I guarantee you'll turn heads.

/// TECHNIQUES

UPDATING THE STAR BOOK

At this writing, the software that runs the Star Book is version 2, build 27. It's likely that, by the time you read this, one or more additional upgrades will have occurred.

To perform upgrades to the Star Book controller, you need a LAN crossover cable (Ethernet Cat 5). This computer cable is available from most computer or electronics stores.

To update the software, first download the latest version from www.vixen.co.jp. Once you arrive at that page, click "English." Then click on "Updating STAR BOOK to ver. 1.X Build XX," where the Xs represent the version later than the one shown on your Star Book. Follow the directions on the web site. The update takes only a few minutes, but don't interrupt it until it's complete.

— Michael E. Bakich

THE STAR BOOK controller's rear panel contains all the connections needed to control the Sphinx mount. The panel is well engineered: All connections are different, so there's no chance that you'll hook something up incorrectly.

THE STAR BOOK hand controller sports a colorful 4.7-inch (120mm) LCD screen that lets you know where the mount is pointing. The Star Book's buttons function differently in different modes, but because a key to the buttons is always displayed on the screen, there's never a question about what they do.

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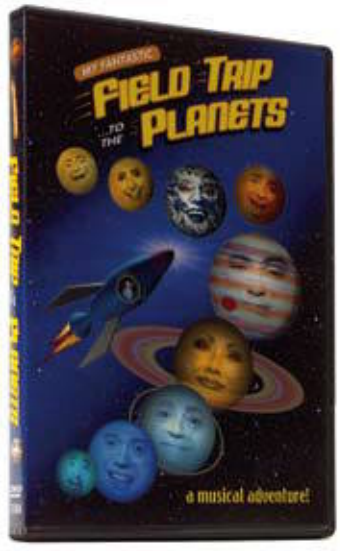

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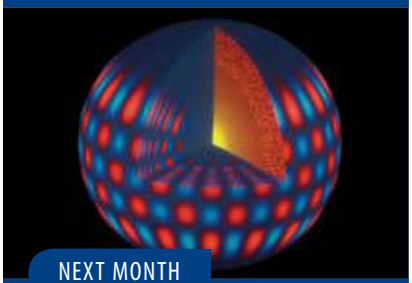

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NEXT MONTH

The music of the spheres
Space is alive with the "sound" of solar flares, black holes, and even the Big Bang.

In search of the first stars
Detecting the earliest stars will help astronomers understand how stars form and unlock secrets to the infant universe.

Odd couples
They pass near Earth, they inhabit the main asteroid belt, and they orbit beyond Pluto. Binary asteroids are everywhere in the solar system, and Dan Durda explains why.

Herschel's quest
In 1833, John Herschel's family name took him to South Africa to map the southern sky, and his determination made him a legend.

The Nagler eyepiece at 25
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For more information on the exhibit, visit www.spaceexhibit.com.

OCTOBER 11
"Einstein's Big Idea"
PBS, *NOVA*. Everybody has heard of it, but what does the world's most famous equation, $E=mc^2$, really mean? *NOVA* dramatizes the stories of the men and women whose innovative thinking led finally to Einstein's bold breakthrough. Based on David Bodanis' best-seller, $E=mc^2$, this fascinating docudrama stars Aidan McArdle as Einstein and Shirley Henderson as his wife Mileva. Check your local listings for broadcast time.

OCTOBER 27–NOVEMBER 5
Friends of the Sky Star Party
Near Portal, Arizona. Because the star party is located just outside the Arizona Sky Village, a dark-sky community, light pollution will not affect observing. During the day, attendees can explore the nearby Chircahua Mountains and Cave Creek Canyon. For more information, visit www.arizonaskyparty.com.

OCTOBER 27–NOVEMBER 5
Chiefland Star Party
Chiefland, Florida. This laid-back star party provides the public a chance to

view and participate in the great activities members of the Chiefland Astronomy Village enjoy year-round. For more information, visit www.c-av.com.

NOVEMBER 1–8
Mid-Atlantic Star Party
Dark Park, near Robbins, North Carolina. The site features some of the darkest skies in the southeastern United States. Wi-Fi Internet connections will be available for attendees. Experienced astrophotographers can submit their images from the star party for a photo contest held on the last day of the event. For more information, e-mail john@masp.org; web site 69.6.212.143/index.shtml.

NOVEMBER 2–5
Eldorado Star Party
X-Bar Ranch, near Sonora, Texas. Sponsored by the Texas Star Party, this event is conveniently accessible from cities across the Lone Star state. The site provides ample space for tents and RVs. A few cabins are available for those who don't want to "rough it." For more information, e-mail espreg@hotmail.com; web site, www.texasstarparty.org/eldorado.html.

NOVEMBER 2–6
Peach State Star Gaze
White Water Express High Adventure Camp, Ducktown, Tennessee. The Atlanta Astronomy Club has created observing challenges for attendees, regardless of equipment, experience, or ability. This event will hold workshops on topics ranging from star-hopping to sky-sketching to CCD imaging. For more information, e-mail pssg@ atlantaastronomy.org; web site, www.atlantaastronomy.org.

NOVEMBER 4
Far Out Friday
Adler Planetarium and Astronomy Museum, Chicago. On the first Friday of every month, the Adler hosts an evening of astronomy-related fun, including observing, lectures, planetarium shows, and tours of the facilities. For more information, call 312.922.7827; web site, www.adlerplanetarium.org.

NOVEMBER 5
North Texas Skywatch Star Party
Lake Mineral Wells State Park, Mineral Wells, Texas. This family-friendly event is hosted by Tarleton State University and Tarrant County College. Participants are encouraged to bring their scopes to share views with beginners who have never looked through an eyepiece. The gathering will feature workshops, a guest speaker, and observing. For more information, call 254.968.9150, web site, www.tarleton edu/~planetarium.

NOVEMBER 13
Astrofestival
University of Oslo, Norway. This seventh annual event features an enormous solar system model, a hunt for space aliens, a simulated surface of Mercury, telescope workshops, and the chance to build a spaceship sponsored by LEGO. For more information, e-mail Michael Baziljevich at michaelb@fys.uio.no; web site, www.astrofestival.no/english.php.

NOVEMBER 15
Family Astronomy
LodeStar Astronomy Center, Albuquerque, New Mexico. Geared toward families, this ongoing program provides hands-on fun that covers a variety of astronomy topics. This month's session is "Your Galactic Address!" For more information, visit www.lodestar.unm.edu.

NOVEMBER 21–DECEMBER 2
Canary Islands Winter School of Astrophysics
Cabildo Insular de Tenerife Conference Center, Puerto de la Cruz, Canary Islands, Spain. The theme for this year's event is "Extrasolar Planets." For more information, visit www.iac.es/winters.

CONTACT INFORMATION
Please submit club announcements 4 months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Also use this e-mail address to submit your events for our online calendar.

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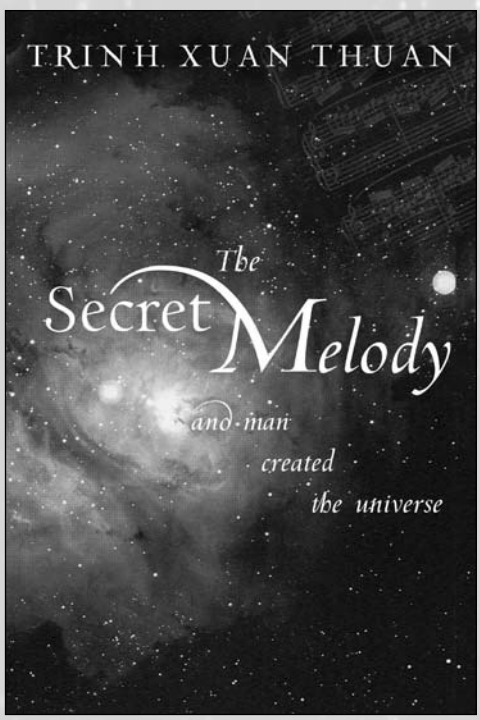

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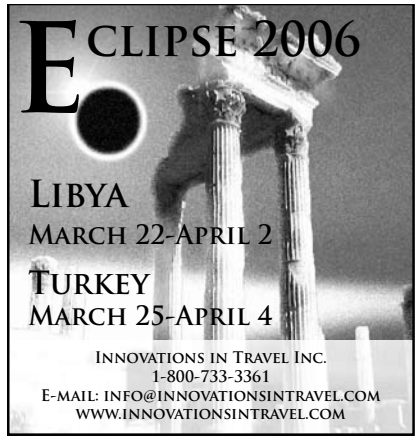

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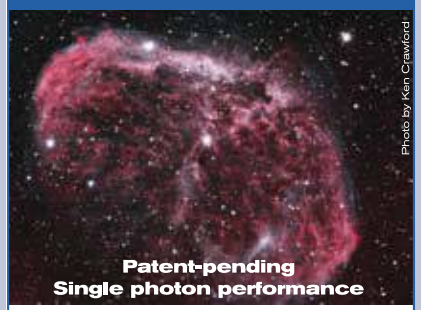

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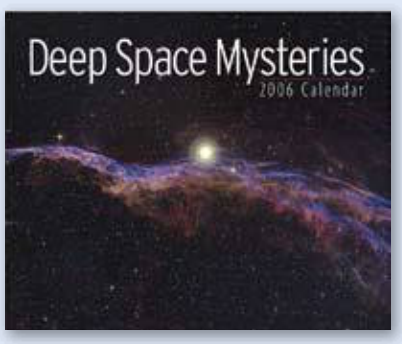

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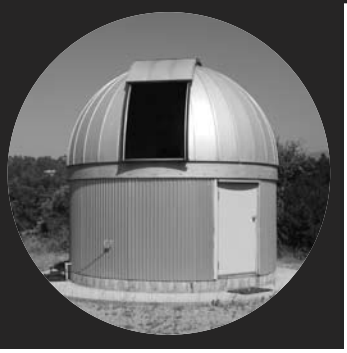

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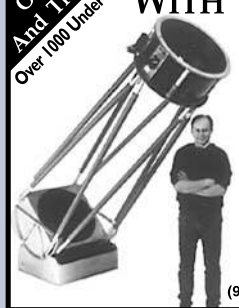

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NGC 4656 and NGC 4631 /// The Running Man Nebula (NGC 1975–7–9)
Jupiter /// The Northern Milky Way /// The IC 1396 nebular complex

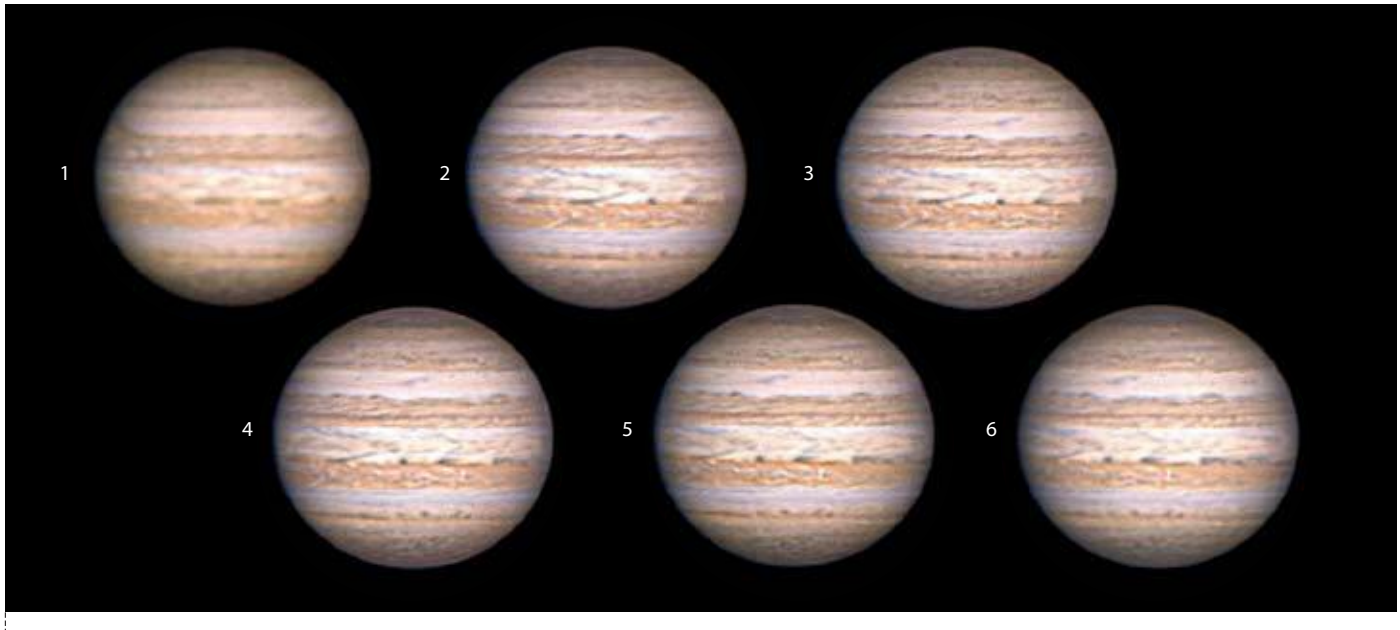
THE HOCKEY STICK (NGC 4656) AND WHALE (NGC 4631) GALAXIES (5.6-inch Telescope Engineering Company APO140 apochromatic refractor, SBIG ST-10XME CCD camera, LRGB image with exposures of 120, 30, 30, and 25 minutes, respectively) /// **RUBEN KIER, ORANGE, CONNECTICUT**

GALACTIC TURMOIL

Two northern galaxies

A pair of galaxies called the Hockey Stick (NGC 4656) and the Whale (NGC 4631) lies roughly 30 million light-years away, within the boundaries of Canes Venatici the Hunting Dogs. Observers gave them their common names because of their unusual shapes. The shapes result from anything but a calm tale of galaxies floating through the void. These star systems — and the smaller elliptical NGC 4627, which appears attached to the whale's back — comprise a small group of galaxies deformed by mutual gravitational interaction. NGC 4631 shines at magnitude 9.8, NGC 4656 glows at magnitude 10.4, and NGC 4627 is faintest at magnitude 12.3.

THE RUNNING MAN NEBULA (NGC 1975–7–9) probably is underobserved for as bright an object as it is. The reason is that it lies ½° north of the spectacular Orion Nebula (M42). /// **JOSE SURO, TIERRA VERDE, FLORIDA**



JUPITER ROTATES QUICKLY, so a short series of images will show its motion. Pick an atmospheric feature, and notice how it moves from right to left as time goes by. (16-inch Newtonian reflector at f/21.7, Atik ATK-2C CCD camera, each image is 725 frames stacked; taken at 1) 3h58m UT, 2) 4h40m UT, 3) 4h55m UT, 4) 5h18m UT, 5) 5h35m UT, and 6) 5h46m UT) /// **DON PARKER, CORAL GABLES, FLORIDA**

THE NORTHERN MILKY WAY shines brightly in the summer. This image shows the region around the 2nd-magnitude star Gamma (γ) Cygni. The abundance of emission nebulae makes the bright star the least interesting object in this image. (12-inch Meade Schmidt camera at f/2.2, 120-format Fuji HG 400 film, two 7-minute exposures digitally combined) /// **JASON WARE, PLANO, TEXAS**

THE NEBULAR COMPLEX IC 1396 in Cepheus combines an emission nebula and a star cluster. With a diameter of 3°, it's one of the largest such complexes in the sky. The orange star on the nebula's lower right edge is Mu (μ) Cephei, also known as Herschel's Garnet Star. IC 1396 lies at a distance of approximately 2,500 light-years. (Pentax K1000 35mm camera, 100mm lens at f/4, Kodak PPF 400 film, 30-minute exposure)
/// **JOHN CHUMACK AT STAR HILL OBSERVATORY, SAPELLO, NEW MEXICO**

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